Guidelines for Reclamation

to Forest Vegetation in the Athabasca Oil Sands Region

Prepared by

Terrestrial Subgroup
Cumulative Environmental Management Association

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In Memoriam

This manual is dedicated to the memory of friend and colleague John David Beckingham, who contributed substantially to this manual and its ecological foundations. John passed away in October of 2008, during development of the manual, but his ideas and dedication live on within.

Foreword

The first edition of the *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region* (subsequently referred to as the Revegetation Manual) was prepared by the Oil Sands Vegetation Reclamation Committee and released in 1998. The Revegetation Manual was recognized as a 'living' document that would require periodic updates as new data became available to improve reclamation practices in the Athabasca Oil Sands Region. In 1999, the Oil Sands Vegetation Reclamation Committee was reconvened, along with the Soils Working Group, to form the Soils and Vegetation Working Group. This group was subsequently integrated into the Cumulative Environmental Management Association (CEMA) as a Subgroup of the Reclamation Working Group (RWG) in 2001-2002, and re-named the Terrestrial Subgroup of RWG in 2009. The Terrestrial Subgroup is currently responsible for the continued refinement of the Revegetation Manual, and has developed this 2nd edition.

RWG is tasked with the production and maintenance of guidance documents, such as the Revegetation Manual, that provide recommendations and best practices to support reclamation within the Athabasca Oil Sands Region that meets regulatory requirements, satisfies the needs and values of stakeholders, and is environmentally sustainable. RWG's work applies to surface mineable oil sands and other surface disturbances including in situ extraction, and derives from the 1999 Regional Sustainable Development Strategy (RSDS). The RSDS identified 72 major issues of concern in 14 theme areas. The RWG's scope of work is derived from the RSDS Theme 1 (sustainable ecosystems and land-use), which was divided into two separate objectives, one of which is being addressed by RWG:

> "To define the process and standards needed to return developed land to sustainable ecosystems with desired end land use values."

In 1999, the Soil and Vegetation Working Group discussed a program required to "calibrate" the Revegetation Manual and the *Land Capability Classification System for Forest Ecosystems in the Oil Sands* (LCCS). A long-term monitoring and calibration program was reviewed and approved by the joint working group, with the pilot phase of the program being implemented in 2000.

Ongoing research and monitoring programs in the region, such as the long-term monitoring and calibration program, provided new data for updating and refining the suggested approaches and techniques in this 2nd edition of the Revegetation Manual.

The 2nd Edition is comprised of the following sections:

- Section 1 describes the historical development of the Revegetation Manual, the changes incorporated into the 2nd edition and the goals and objectives of the Revegetation Manual.
- Section 2 describes approaches to the use of the manual, and presents decision-flow structures in support of these approaches.
- Section 3 defines the Edatopic Grid, ecosites and site types, and presents a table of characteristic species for ecosites and site types in the Athabasca Oil Sands Region.
- Section 4 describes end land-use declaration and appropriate revegetation targets for the declared end land-use.
- Section 5 describes indicators of revegetation success and methods to assess these indicators on reclaimed landscapes.
- Section 6 provides a glossary of terms relevant to reclamation in Alberta.

The following 10 appendices are included in the 2nd Edition:

- Appendix A—Acts and Regulations
- Appendix B—Key Concepts in Monitoring
- Appendix C—Soil Salinity
- Appendix D—Wildlife Populations and Habitat Capability in the Oil Sands Region
- Appendix E—Revegetation Considerations for Traditional Land-Use
- Appendix F—Plant Species Fact Sheets
- Appendix G—Planting Prescriptions on Reclaimed Landscapes Receiving LFH Amendments
- Appendix H—Seed Zones, Sources and Regulations
- Appendix I—List of Species in the Oil Sands Region
- Appendix J—Estimating Ecosite Based on Species Lists

The Revegetation Manual is intended to be used by government and industry staff as outlined in the *Environmental Protection and Enhancement Act* Approvals for Operators.

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1. Introduction

1.1. Background

In 1996, the Oil Sands Vegetation Reclamation Committee was formed to prepare guidelines on the establishment of forest vegetation and ecosystems, with an emphasis on providing appropriate "starter vegetation" to use for reclaiming oil sands leases in northeastern Alberta. The outcome of this process, the first edition of the *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region* (subsequently referred to as the Revegetation Manual), was released in 1998. In 1999, the committee was reconvened, along with the Soils Working Group, to form the Soils and Vegetation Working Group, which was integrated into the Cumulative Environmental Management Association (CEMA) as a Subgroup of the Reclamation Working Group in 2001-2002. In 2009, the Soils and Vegetation Subgroup was renamed the Terrestrial Subgroup. The Terrestrial Subgroup (TSG) of CEMA is currently responsible for the continued refinement of the Revegetation Manual, and has developed this 2nd edition. When the first edition of the Revegetation Manual was issued, it was acknowledged that it needed to be a "living document" requiring periodic revision. The original goal for revision schedule was that a new manual would be issued based on updated information every five years. It is acknowledged that the state of knowledge around reclamation in the oil sands region remains incomplete, and that periodic revision of this manual will be required as new information becomes available. It is an explicit assumption of this manual that it is to provide guidance on reclamation activities for the approximate period from date of issue until 2014-2019, or until reclamation knowledge has advanced sufficiently to justify a revision.

This Revegetation Manual incorporates a number of substantial changes from the 1998 version, as summarized below:

- The Land Capability Classification System (LCCS) is used to estimate soil moisture and nutrient regimes on reclaimed sites. This estimate is then used to identify target ecosites and corresponding appropriate species for revegetation of these sites. This change is intended to provide a more direct link between the principal soils evaluation tool used in the oil sands region, the LCCS, and revegetation guidance provided in this manual.

- Guidance on overstory planting densities is based on projected trends in tree growth and mortality over time, as guided by regional plot data. This guidance differs substantially from the uniform prescriptions presented in the 1998 manual.

- A range of understory species appropriate to target ecosites are presented, along with detailed fact sheets on these species, where available, in an appendix.

- Guidance on the use of surface soil materials as a propagule source – including guidance with respect to modification of overstory and understory planting densities – is presented.

- A number of indicators of revegetation success, and corresponding thresholds for evaluation of a sub-set of these indicators, are presented.

- Introduction of the use of the "site type" - a broader ecological classification unit than ecosite - as the classification unit for evaluation of vegetation communities on reclaimed sites.

These changes have been guided by results from the 1999-2009 TSG workplan.

1.2. Scope of the Document

As with the previous version, this edition of the Revegetation Manual emphasizes the techniques and methodologies necessary to establish upland forest plant species and ecosystems appropriate to given site conditions and reclamation objectives. The decision sequence is developed using two flow charts (see Section 2), each of which begins at a different stage in the decision-making process. At each decision point (within a given flow chart), the user is directed to details regarding specific aspects of revegetation practices or monitoring activities. The final activity is an evaluation procedure to assist in determining whether revegetation objectives have been met.

1.3. Goal and Objectives

The goal of this manual is to provide guidance on re-establishing the vegetation component of upland ecosystems on reclaimed landscapes, and on evaluating the success of this re-establishment. This goal is based on the following fundamental concepts:

1. That reclaimed plant communities should have species characteristic of native plant communities in the oil sands region.

2. That trends of vegetation community and structure development on reclaimed landscapes should be similar to native plant communities in the oil sands region.

3. That reclaimed ecosystems should have developmental trajectories that satisfy land-use objectives, and have characteristics that provide resilience against natural disturbance events.

There are a number of specific objectives addressed in this manual that contribute to the above goal and underlying concepts, and advance the Revegetation Manual beyond the first edition. These include:

- **Increase flexibility in revegetation treatments** - the 1st edition of the Revegetation Manual focused on ecosite phases (specific overstory communities occupying specific edaphic positions) as revegetation targets. This version of the manual recognizes the considerable species overlap between ecosite phases, and uses the broader ecosite category as the primary revegetation target. In addition, the manual introduces the concept of "site types" - an ecological classification unit broader than ecosites - as the principal target for evaluation purposes. These modifications allow for greater flexibility in revegetation treatments, and to acknowledge uncertainty in estimation of edaphic position on new reclaimed landscapes.

- **Provide methods to evaluate the success of revegetation measures** - this manual acknowledges that greater flexibility is needed in planning and implementing revegetation treatments on reclaimed landscapes, but also that methods and standards for evaluating the success of these treatments are needed. To this end, the manual introduces a number of indicators of ecosystem function, and an approach to evaluating revegetation success (Section 5). These indicators include:

  - "Hard" indicators, which have measurement protocols, thresholds, and reclamation certification implications,
  - "Soft" indicators, for which further development is needed, and
  - An intermediate category.

- **Provide a more direct linkage to soil salvage and placement activities informed by the LCCS and the revegetation activities informed by this manual** – as discussed in Section 1.1 above, and Section 2.

- **Provide an explicit list of knowledge gaps encountered during this revision process, which can inform future work plans targeted in the next Revegetation Manual revision.**

1.4. How to Use the Manual

The process of developing and implementing a revegetation program begins in Section 2. Decision-making is guided through the use of conceptual flow charts that define the principal focus of the revegetation program. There are two options/approaches for these flow charts:

1. The **ecosite/site type** approach assumes that revegetation treatments are being developed for designed reclamation caps, from which an appropriate ecosite/site type and end land-use objective is defined. Detailed descriptions of site type and land-use objectives are provided in Sections 3 and 4, respectively. The revegetation program is then developed accordingly, the details of which are provided in Section 4.
2. The **land-use approach**, in contrast, begins by defining a land-use objective and an associated site type. A reclamation cap can then be designed to satisfy the specified objective, and a revegetation plan developed. The land-use approach thus represents a means to "reverse engineer" the capping prescription in order to achieve a previously defined objective.

Information on indicators of revegetation success and assessment of these indicators is presented in Section 5 (and Appendix B).

2. Manual Structure and Decision Flow

The first step in using the information contained in this manual is to select a starting point for revegetation planning. The manual presents two options, as defined below:

1. **Ecosite/Site Type Approach** (see Figure 2-1) - This approach assumes that the starting point for revegetation planning is an existing landform and reclamation cap design needing revegetation (this approach could also be used for existing landforms/caps, but it is assumed that revegetation planning will typically start in the design phases). In this case, the primary task of revegetation planning is to select revegetation treatments appropriate to site conditions, as guided by desired end land-uses. This approach would typically be used in reclamation planning on operational mine sites, where reclamation and closure plans are well developed and guided by mine planning constraints.

2. **End Land-use Approach** (see Figure 2-2) - This approach assumes that the primary drivers for revegetation planning are end land-use objectives, and that landform and/or capping designs can be adjusted to meet these objectives. This approach might typically be used earlier in the mine design process (e.g., at the application or closure planning stages). The end land-use approach differs from the site type approach in that it constitutes a planning exercise for both the capping and revegetation prescriptions (only the latter occurs under the site type approach). Note that only planning for revegetation is described in this document. Development of an appropriate capping prescription should be conducted in conjunction with the LCCS (Alberta Environment 2006), once the target ecosite/site type has been identified (see below).

   In practice, there is little conceptual difference between the two presented approaches - the end land-use approach simply describes a "reverse engineering" of the ecosite/site type approach, to allow modification of the reclamation process to meet revegetation objectives. In reality it is likely that most revegetation programs will be developed using elements of both approaches.

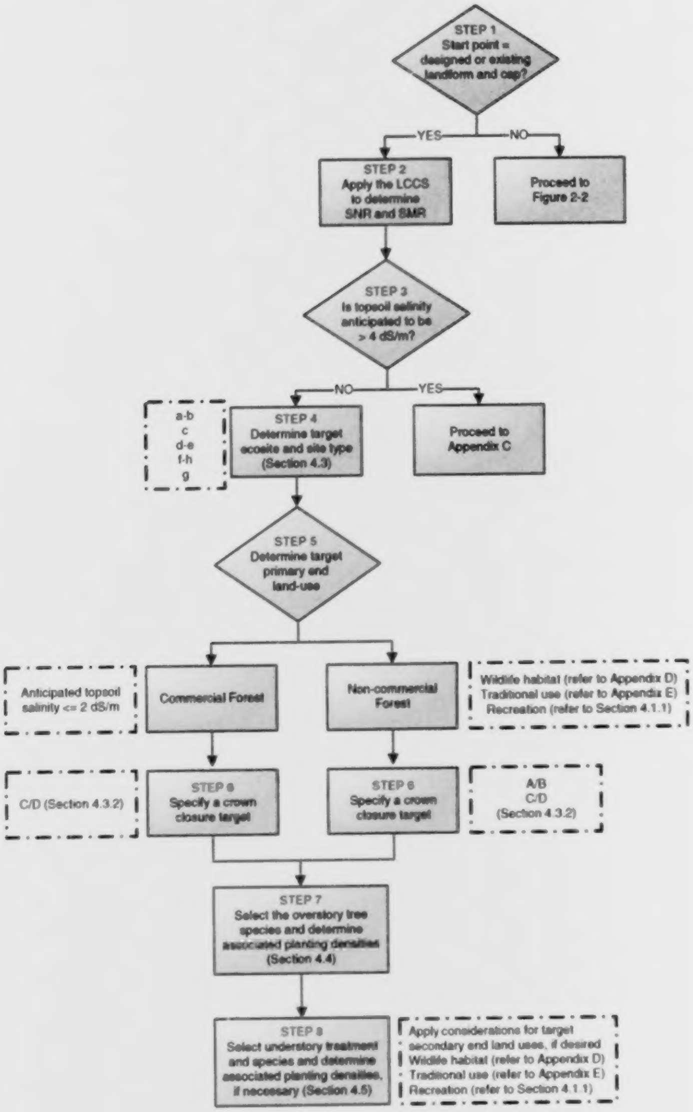

STEP 1
Start point = designed or existing landform and cap?
YES
NO
STEP 2
Apply the LCCS to determine SNR and SMR
Proceed to Figure 2-2
STEP 3
Is topsoil salinity anticipated to be > 4 dS/m?
NO
YES
a-b
c
d-e
f-h
g
STEP 4
Determine target ecosite and site type (Section 4.3)
Proceed to Appendix C
STEP 5
Determine target primary end land-use
Anticipated topsoil salinity <= 2 dS/m
Commercial Forest
Non-commercial Forest
Wildlife habitat (refer to Appendix D)
Traditional use (refer to Appendix E)
Recreation (refer to Section 4.1.1)
C/D (Section 4.3.2)
STEP 6
Specify a crown closure target
STEP 6
Specify a crown closure target
A/B
C/D
(Section 4.3.2)
STEP 7
Select the overstory tree species and determine associated planting densities (Section 4.4)
STEP 8
Select understory treatment and species and determine associated planting densities, if necessary (Section 4.5)
Apply considerations for target secondary end land uses, if desired
Wildlife habitat (refer to Appendix D)
Traditional use (refer to Appendix E)
Recreation (refer to Section 4.1.1)

Figure 2-1 **Ecosite/site type approach**

This approach is used when there is a designed or existing landform and reclamation cap requiring revegetation. Steps outlined below correspond to numbered steps in the figure.

1. Confirm that the ecosite/site type approach is applicable. If not, consult Figure 2-2.
2. Determine estimated Soil Moisture Regime (SMR) and Soil Nutrient Regime (SNR) for the site, using the LCCS manual.

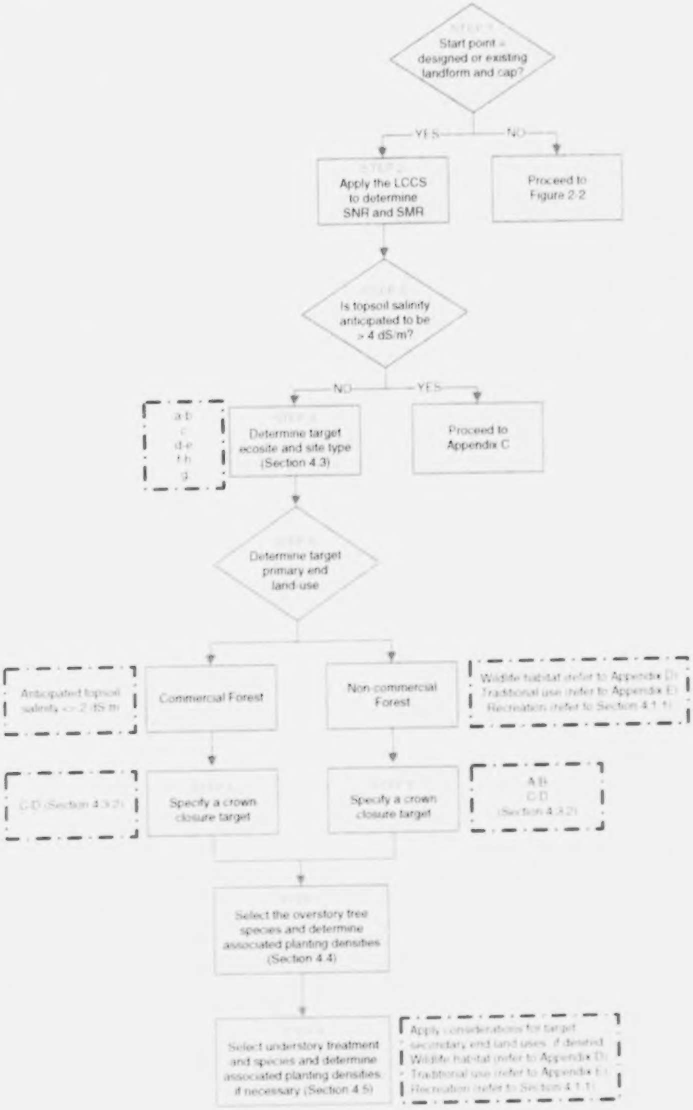

Start point = designed or existing landform and cap?
YES
NO
STEP 2
Apply the LCCS to determine SNR and SMR
Proceed to Figure 2-2
Is topsoil salinity anticipated to be > 4 dS/m?
NO
YES
a-b
c
d-e
f-h
g
Determine target ecosite and site type (Section 4.3)
Proceed to Appendix C
Determine target primary end land use
Anticipated topsoil salinity <= 2 dS/m
Commercial Forest
Non-commercial Forest
Wildlife habitat (refer to Appendix D)
Traditional use (refer to Appendix E)
Recreation (refer to Section 4.1.1)
C-D (Section 4.3.2)
Specify a crown closure target
Specify a crown closure target
A-B
C-D
(Section 4.3.2)
Select the overstory tree species and determine associated planting densities (Section 4.4)
Select understory treatment and species and determine associated planting densities, if necessary (Section 4.5)
Apply considerations for target secondary end land uses, if desired
Wildlife habitat (refer to Appendix D)
Traditional use (refer to Appendix E)
Recreation (refer to Section 4.1.1)

Figure 2-1 **Ecosite/site type approach**

This approach is used when there is a designed or existing landform and reclamation cap requiring revegetation. Steps outlined below correspond to numbered steps in the figure.

1. Confirm that the ecosite/site type approach is applicable. If not, consult Figure 2-2.
2. Determine estimated Soil Moisture Regime (SMR) and Soil Nutrient Regime (SNR) for the site, using the LCCS manual.

3. Evaluate potential limiting soil factors. In this manual, the only limiting factor considered is salinity. If topsoil (as defined by the LCCS, 0-20 cm below ground surface) salinity exceeds 4 dS/m, revegetation using typical forest species is not appropriate. The user is directed to Appendix C, where guidance on revegetation using salt-tolerant species is provided.

4. Determine target ecosite and site type. These concepts are introduced in Section 3, with further information on making this determination included in Section 4. This manual covers upland ecosystems, or ecosites a through h, and associated site types.

5. Determine target primary end land-use. End land-uses are introduced in Section 4, and include commercial and non-commercial forests. Non-commercial forest end land-uses include wildlife habitat, traditional use, and recreation. Although the user is directed to determine a single primary end land-use, in reality multiple end land-uses can and will occur simultaneously in reclaimed forest stands.

    - **Commercial Forest** – commercial forest can only occur where soil salinity levels do not preclude productive tree growth. This selection is limited to sites where anticipated topsoil salinity is less than or equal to 2 dS/m.

    - **Non-commercial Forest** – consult Appendices D and E and Section 4.1.1 for relevant guidance on reclamation to these end land-uses.

6. Specify a crown closure target. Crown closure targets are based on desired stand characteristics at maturity or rotation age, with labels based on Alberta Vegetation Inventory (AVI) conventions. Crown closure classes A and B represent relatively open stands (6-50% crown closure), while classes C and D represent closed stands (>50% crown closure). Because commercial forests require fully stocked stands, identification of commercial forest as the primary end land-use precludes selection of open crown closure classes, which constrains crown closure targets for commercial forest to classes C/D. Selection of crown closure targets for non-commercial forest end land-uses is unconstrained. Open stands may be selected where reclamation objectives require a sparse overstory with higher understory light levels (e.g., production of understory species for wildlife habitat and/or traditional use).

7. Select the overstory tree species and determine associated planting densities. Overstory tree species selection is based on identification of species appropriate to the estimated ecosite. Detailed guidance on this step is provided in Section 4.4.

8. Select understory treatment and species. As with the overstory, understory species selection is based on identification of species appropriate to the estimated ecosite. Detailed guidance on this step is provided in Section 4.5. This stage provides an opportunity to incorporate considerations of desired secondary end land-uses. This is particularly appropriate when commercial forest has been selected as the primary end land-use, but there is a desire to incorporate understory elements for wildlife habitat and/or traditional use.

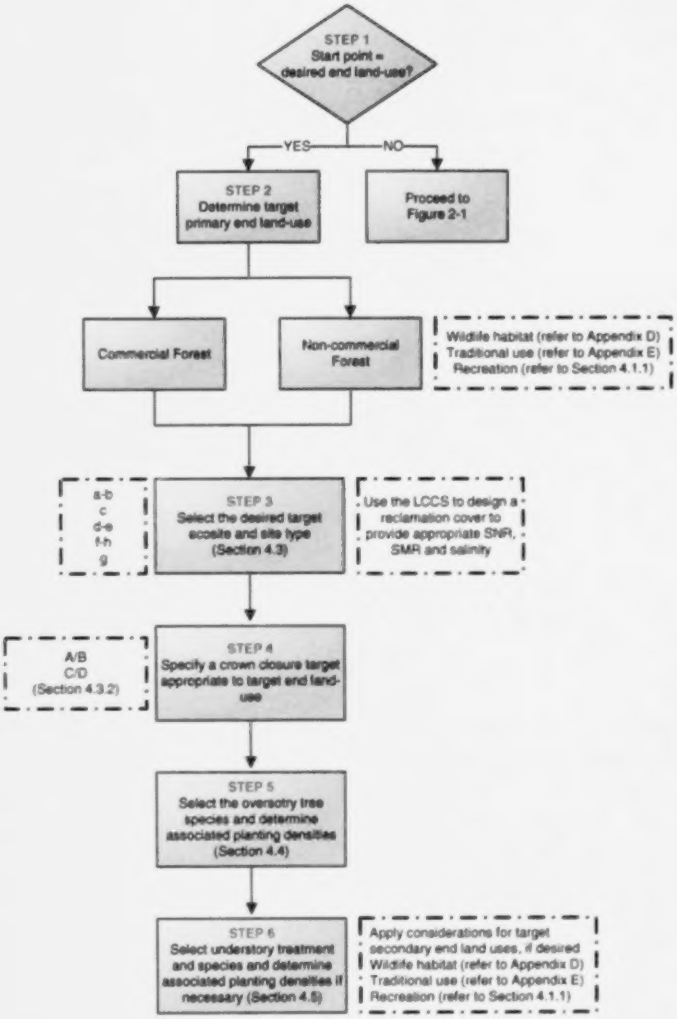

STEP 1
Start point = desired end land-use?
YES
NO
STEP 2
Determine target primary end land-use
Proceed to Figure 2-1
Commercial Forest
Non-commercial Forest
Wildlife habitat (refer to Appendix D)
Traditional use (refer to Appendix E)
Recreation (refer to Section 4.1.1)
a-b
c
d-e
f-h
g
STEP 3
Select the desired target ecosite and site type (Section 4.3)
Use the LCCS to design a reclamation cover to provide appropriate SNR, SMR and salinity
A/B
C/D
(Section 4.3.2)
STEP 4
Specify a crown closure target appropriate to target end land-use
STEP 5
Select the overstory tree species and determine associated planting densities (Section 4.4)
STEP 6
Select understory treatment and species and determine associated planting densities if necessary (Section 4.5)
Apply considerations for target secondary end land uses, if desired
Wildlife habitat (refer to Appendix D)
Traditional use (refer to Appendix E)
Recreation (refer to Section 4.1.1)

Figure 2-2 **End land-use approach**

This end land-use approach is used when the goal is to design reclamation to achieve specified end land-use objectives. Steps outlined below correspond to numbered steps in Figure 2-2.

1. Confirm that the end land-use approach is applicable. If not, consult Figure 2-1.

2. Determine the primary desired end land-use. End land-uses are introduced in Section 4, and include commercial and non-commercial forests. Non-commercial forest end land-uses include wildlife habitat, traditional use, and recreation. Although the user is directed to determine a single primary end land-use, in reality multiple end land-uses can and will occur simultaneously in reclaimed forest stands. Regardless of primary end land-use selection, most

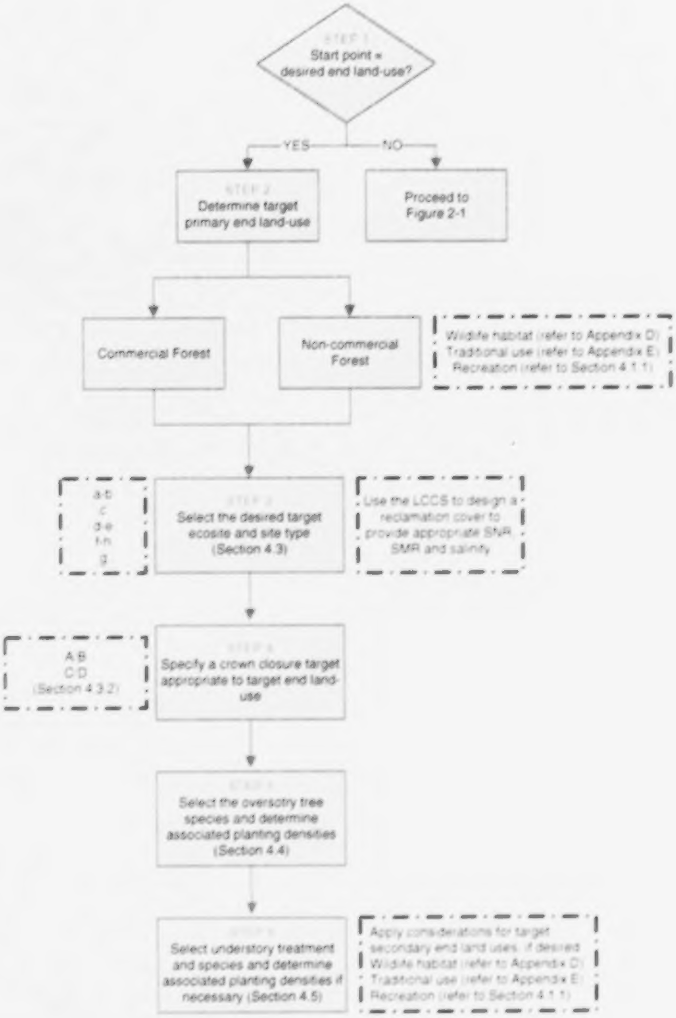

STEP 1
Start point = desired end land-use?
YES
NO
STEP 2
Determine target primary end land-use
Proceed to Figure 2-1
Commercial Forest
Non-commercial Forest
Wildlife habitat (refer to Appendix D)
Traditional use (refer to Appendix E)
Recreation (refer to Section 4.1.1)
a-b
c
d-e
f-h
g
STEP 3
Select the desired target ecosite and site type (Section 4.3)
Use the LCCS to design a reclamation cover to provide appropriate SNR, SMR and salinity
A,B
C,D
(Section 4.3.2)
STEP 4
Specify a crown closure target appropriate to target end land-use
STEP 5
Select the oversotry tree species and determine associated planting densities (Section 4.4)
STEP 6
Select understory treatment and species and determine associated planting densities if necessary (Section 4.5)
Apply considerations for target secondary end land uses, if desired
Wildlife habitat (refer to Appendix D)
Traditional use (refer to Appendix E)
Recreation (refer to Section 4.1.1)

Figure 2-2 **End land-use approach**

This end land-use approach is used when the goal is to design reclamation to achieve specified end land-use objectives. Steps outlined below correspond to numbered steps in Figure 2-2.

1. Confirm that the end land-use approach is applicable. If not, consult Figure 2-1.

2. Determine the primary desired end land-use. End land-uses are introduced in Section 4, and include commercial and non-commercial forests. Non-commercial forest end land-uses include wildlife habitat, traditional use, and recreation. Although the user is directed to determine a single primary end land-use, in reality multiple end land-uses can and will occur simultaneously in reclaimed forest stands. Regardless of primary end land-use selection, most

steps in the revegetation planning process are similar; however, the user is directed to supplementary information in appendices for the non-commercial forest end land-uses, and is subject to certain constraints on selection of a commercial forest end land-use.

- **Commercial Forest** - Commercial forest can only occur where soil salinity levels do not preclude productive tree growth. This selection is limited to sites where anticipated topsoil salinity is less than or equal to 2 dS/m.
- **Non-commercial Forest** - Consult Appendices D and E and Section 4.1.1 for relevant guidance on reclamation to these end land-uses.

3. Select the desired target ecosite and site type. These concepts are introduced in Section 3, with further information on making this determination included in Section 4. Determination of ecosite and site type will be guided by specifics of end land-use objectives (e.g., commercial hardwood stand, mixedwood stand for moose habitat), so it may be guided by other planning documents such as Forest Resource Plans or by the end land-use guidance provided in Appendices D and E and Section 4.1.1 of this manual. This manual covers upland ecosystems, or ecosites a through h, and associated site types. Each ecosite/site type has an associated moisture and nutrient regime (its position on the Edatopic Grid; see Section 3 for details) to which it is best suited. At the point that the desired ecosite/site type is selected, the LCCS can be used to inform soil replacement actions to generate soil moisture and nutrient regimes (and salinity conditions) appropriate to these selected ecosystems.

4. Specify a crown closure target (Section 4.3.2). Crown closure targets are based on desired stand characteristics at maturity or rotation age, with labels based on AVI conventions. Crown closure classes A and B represent relatively open stands (6-50% crown closure), while classes C and D represent closed stands (>50% crown closure). Because commercial forests require fully stocked stands, identification of commercial forest as the primary end land-use precludes selection of open crown closure classes, so crown closure targets for commercial forest are constrained to classes C/D. Selection of crown closure targets for non-commercial forest end land-uses is unconstrained. Open stands may be selected where reclamation objectives require a sparse overstory with higher understory light levels (e.g., production of understory species for wildlife habitat and/or traditional use).

5. Select the overstory tree species and determine associated planting densities. Overstory tree species selection is based on identification of species appropriate to the estimated ecosite. Detailed guidance on this step is provided in Section 4.4.

6. Select understory treatment and species. As with the overstory, understory species selection is based on identification of species appropriate to the estimated ecosite. Detailed guidance on this step is provided in Section 4.5. This stage provides an opportunity to incorporate considerations of desired secondary end land-uses. This is particularly appropriate when commercial forest has been selected as the primary end land-use, but there is a desire to incorporate understory elements for wildlife habitat and/or traditional use.

The two approaches presented in Figures 2-1 and 2-2 focus on re-establishment of plant communities at the stand level by determining either:

a) The LCCS SMR and SNR and target ecosite/site type; or

b) A target end land-use; and deploying treatments and introducing plant species to achieve the stand level objectives.

The ecosite/site type approach and the end land-use approach do not address methods of planning for a distribution of plant community structures and compositions across a landscape - whether defined as a single development lease or grouping of contiguous leases. This type of broader spatial exercise is a requirement for integrated reclamation planning across the closure landscape.

Researching and developing the potential of spatial modeling as a mechanism for supporting the retention of critical plant communities over space and time is a logical next step in the development of tools for integrated reclamation planning in the oil sands. Information predicted by wildlife habitat suitability indices (HSIs), commercial forestry potential (site indices) and traditional use values could form the basis of spatial modeling of land-use objectives. Approaches to how this might be done and efforts to form a consensus regarding how this might be undertaken will be explored as part of an ongoing process of setting the stage for the 3rd edition of the Revegetation Manual.

3. The Edatopic Grid, Ecosites and Site Types

One of the fundamental concepts utilized in this manual is the Edatopic Grid. This grid represents combinations of soil moisture and nutrient regimes. The manual relies on the Edatopic Grid to communicate information on the plant communities typically associated with these combinations, both in "natural" (non-mined) and reclaimed sites. The grid also provides a basis for linking the Revegetation Manual to the LCCS. The LCCS estimates the edatopic position of reclaimed sites, which can then be used as an input variable in this manual for planning revegetation strategies appropriate to a given set of soil and landscape conditions.

Plant establishment, survival, and growth are assumed to be governed by one or more of five major controlling factors (CEMA 2006a): moisture, nutrients, soil aeration, soil temperature, and competition. These factors are also influenced by a site's climate, geology, and landscape position, and, to varying degrees, they all influence each other. For example, soil temperature is governed mainly by the interaction between climate, soil type, and existing vegetation. Soil nutritional status reflects aspects of climate, geology, and soil temperature and moisture. The relative importance of a given factor varies in relation to different positions on the edatopic grid (an example of the relationship between edaphic factors and competition is illustrated in Figure 3-1). In cases where productivity is strongly limited by the abiotic environment (excessively dry or wet sites), competition is generally low, particularly in the early stages of establishment, since the unfavourable conditions result in low establishment success and seldom allow plants to achieve full site occupancy. In contrast, sites with submesic to subhygric moisture regimes and nutrient regimes of medium or better generate the highest productivity since abiotic conditions are generally favourable. Here, competition can be severe as plants establish quickly and growing space is rapidly reduced.

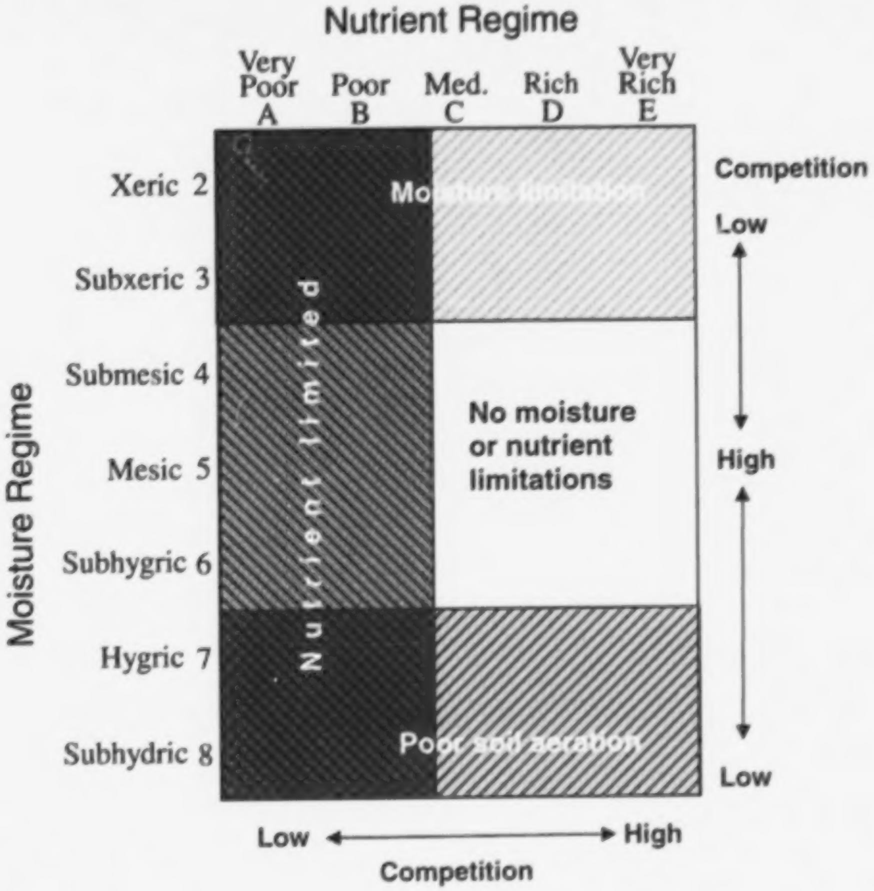
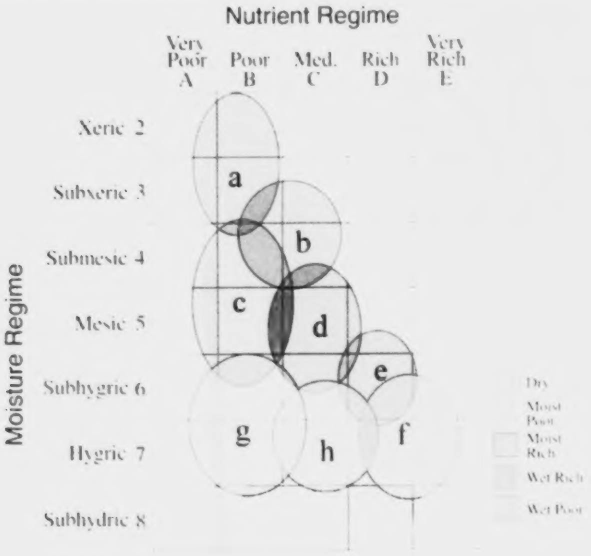

Nutrient Regime
Very Poor A
Poor B
Med. C
Rich D
Very Rich E
Moisture Regime
Xeric 2
Subxeric 3
Submesic 4
Mesic 5
Subhygric 6
Hygric 7
Subhydric 8
Moisture limitation
Nutrient limited
No moisture or nutrient limitations
Poor soil aeration
Competition
Low
High
Low
Low
High
Competition

Figure 3-1 **The Edatopic Grid. The intersection of moisture and nutrient regimes defines the general features dictating plant growth, and these are reflected in the level of competition (modified from CEMA 2006A). Note that the actual level of competition in a given area of the grid is determined by which of moisture or nutrients is most limiting**

Plant species have evolved strategies in response to the site limitations illustrated in Figure 3-1 (e.g., drought tolerance, nitrogen fixation or mycorrhizal associations for nutrient limitations). These strategies define the assemblage of species capable of establishment and co-existence on a given site - the plant communities that characterize a given edatopic position. In Alberta, these communities are classified according to their position on the edatopic grid (the ecosite), their overstory composition (the ecosite phase), and at the finest scale, the plant community type (based on their understory species composition) (Beckingham and Archibald, 1996).

The ecosites of northeastern Alberta and their relationship to the edatopic grid are presented in Figure 3-2. This figure also illustrates a broader vegetation classification unit used in this manual, the site type (see CEMA 2006a). As stated in Section 1.3, the site type concept was developed to acknowledge uncertainty in defining the edatopic position on young reclaimed sites, and to reflect the considerable species overlap between adjacent ecosites.


Nutrient Regime
Very Poor A
Poor B
Med. C
Rich D
Very Rich E
Moisture Regime
Xeric 2
Subxeric 3
Submesic 4
Mesic 5
Subhygric 6
Hygric 7
Subhydric 8
a
b
c
d
e
f
g
h
Dry
Moist Poor
Moist Rich
Wet Rich
Wet Poor

SITE TYPE	ECOSITES:	
Dry	a	**lichen** subxeric poor
	b	**blueberry** submesic medium
Moist Poor	c	**Labrador tea–mesic** mesic poor
Moist Rich	d	**low-bush cranberry** mesic medium
	e	**dogwood** subhygric rich
Wet Rich	f	**horsetail** hygric rich
SITE TYPE Wet Poor	g	**Labrador tea–subhygric** subhygric poor
	h	**Labrador tea/horsetail** hygric medium

Figure 3-2 **Five site types characteristic of the boreal mixedwood region (dry, moist poor, moist rich, wet rich, wet poor), their associated ecosites, and positions on the Edatopic Grid (modified from CEMA 2006A)**

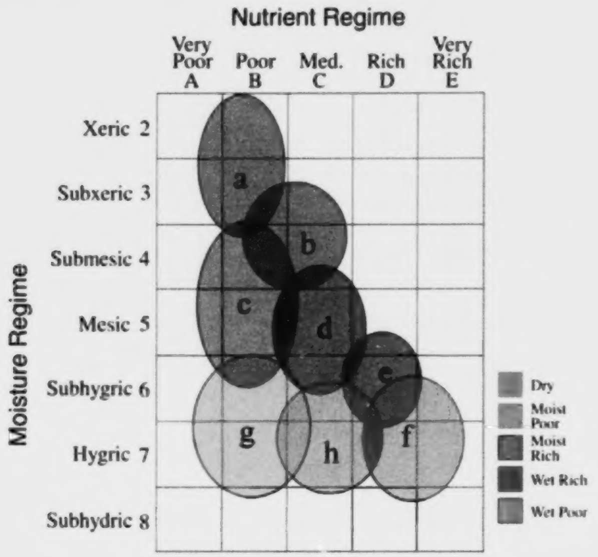
Site types are generally based on groups of ecosites with similarities in their ecological and tree productivity characteristics, as follows:

1. An overlap in dominant and subdominant tree species; and
2. Similarity in soil moisture and nutrient regimes.

It is expected that plant communities within each site type will respond to treatment or intervention in a similar manner.

Site types used in this manual include:

- Dry site type (sharing characteristics of ecosites a and b);
- Moist Poor site type (characteristic of ecosite c);
- Moist Rich site type (sharing characteristics of ecosites d and e);
- Wet Poor site type (characteristic of ecosite g); and
- Wet Rich site type (sharing characteristics of ecosites f and h).



SITE TYPE **ECOSITES:**

Dry
a = **lichen** subxeric/poor
b = **blueberry** submesic/medium

Moist Poor — c = **Labrador tea–mesic** mesic/poor

Moist Rich
d = **low-bush cranberry** mesic/medium
e = **dogwood** subhygric/rich

Wet Rich
f = **horsetail** hygric/rich
h = **Labrador tea/horsetail** hygric/medium

SITE TYPE
Wet Poor — g = **Labrador tea–subhygric** subhygric/poor

Figure 3-2 **Five site types characteristic of the boreal mixedwood region (dry, moist poor, moist rich, wet rich, wet poor), their associated ecosites, and positions on the Edatopic Grid (modified from CEMA 2006A)**

Site types are generally based on groups of ecosites with similarities in their ecological and tree productivity characteristics, as follows:

1. An overlap in dominant and subdominant tree species; and
2. Similarity in soil moisture and nutrient regimes.

It is expected that plant communities within each site type will respond to treatment or intervention in a similar manner.

Site types used in this manual include:

- Dry site type (sharing characteristics of ecosites a and b);
- Moist Poor site type (characteristic of ecosite c);
- Moist Rich site type (sharing characteristics of ecosites d and e);
- Wet Poor site type (characteristic of ecosite g); and
- Wet Rich site type (sharing characteristics of ecosites f and h).

This manual utilizes the term "characteristic species" to identify those species typically found in the undisturbed, native plant communities in the oil sands region. These species are important because one of the fundamental goals of revegetation activities on reclaimed landscapes is to re-establish communities of characteristic species and/or create conditions favourable to their natural re-establishment (see Section 1.3). Characteristic species for the eight ecosites and five site types used in this manual are presented in Table 3-1. A discussion of characteristic species is found in the Ecosite Guide to Northern Alberta (Beckingham and Archibald, 1996). Characteristic species are defined as those species that are either:

a. Present in a minimum of 70% of the sample plots for a given vegetation class; or
b. Have a prominence value of 20 or greater, where prominence value = $\sqrt{\%\ \text{frequency} \times \%\ \text{cover}}$

Information on identification of characteristic species for the vegetation classes used in this manual, and relevant to the oil sands region, is found in (GDC and FORRx 2008).

Table 3-1 Summary of characteristic plant species for uplands ecosites and site types

Scientific name	Common name	Ecosite / Site Type							
		a	b	c	d	e	g	f	h
		Dry		Moist Poor	Moist Rich		Wet Poor	Wet Rich	
Tree Stratum									
Abies balsamea	balsam fir				✓	✓		✓	
Betula papyrifera	white birch		✓		✓	✓		✓	
Picea glauca	white spruce		✓		✓	✓		✓	✓
Picea mariana	black spruce			✓	✓		✓		✓
Pinus banksiana	jack pine	✓	✓	✓			✓		
Populus balsamifera	balsam poplar				✓	✓		✓	
Populus tremuloides	aspen		✓		✓	✓		✓	
Shrub Stratum									
Alnus viridis	green alder	✓	✓	✓	✓	✓		✓	
Alnus incana spp. *tenuifolia*	river alder					✓			
Amelanchier alnifolia	saskatoon		✓		✓	✓			
Aralia nudicaulis	wild sarsaparilla		✓		✓	✓		✓	
Arctostaphylos uva-ursi	common bearberry	✓	✓						
Cornus stolonifera	red-osier dogwood					✓		✓	
Corylus cornuta	beaked hazelnut				✓				
Empetrum nigrum	crowberry			✓					
Hudsonia tomentosa	sand heather	✓							
Ledum groenlandicum	common Labrador tea	✓		✓	✓		✓		✓
Linnaea borealis	twinflower	✓	✓	✓	✓	✓	✓	✓	✓
Lonicera involucrata	bracted honeysuckle					✓			
Ribes americanum	wild black currant				✓	✓		✓	
Ribes glandulosum	skunk currant					✓		✓	
Ribes hudsonianum	northern blackcurrant					✓		✓	
Ribes lacustre	bristly black currant				✓	✓		✓	
Ribes oxyacanthoides	northern gooseberry				✓	✓		✓	
Ribes triste	wild red currant				✓				
Rosa acicularis	prickly rose		✓	✓	✓	✓	✓	✓	✓
Rubus idaeus	wild red raspberry				✓	✓		✓	
Rubus pubescens	dewberry				✓	✓		✓	
Salix athabascensis	Athabasca willow		✓	✓	✓	✓		✓	
Salix bebbiana	beaked willow		✓	✓	✓	✓		✓	
Salix discolor	pussy willow		✓	✓	✓	✓		✓	
Salix drummondiana	Drummond's willow		✓	✓	✓	✓		✓	
Salix glauca	smooth willow		✓	✓	✓	✓		✓	
Salix myrtillifolia	myrtle-leaved willow		✓	✓	✓	✓		✓	
Salix scouleriana	Scouler's willow		✓	✓	✓	✓		✓	
Salix spp.	willow					✓		✓	✓
Shepherdia canadensis	Canada buffaloberry		✓		✓				
Symphoricarpos albus	snowberry				✓				
Vaccinium myrtilloides	common blueberry	✓	✓	✓			✓		
Vaccinium vitis-idaea	bog cranberry	✓	✓	✓			✓		✓
Viburnum edule	low-bush cranberry				✓	✓		✓	

Scientific name	Common name	Ecosite / Site Type							
		a	b	c	d	e	g	f	h
		Dry		Moist Poor	Moist Rich		Wet Poor	Wet Rich	
Forb Stratum									
Aster conspicuus	showy aster				✓				
Cornus canadensis	bunchberry		✓	✓	✓	✓	✓	✓	✓
Epilobium angustifolium	common fireweed		✓		✓	✓			
Equisetum arvense	common horsetail					✓		✓	✓
Equisetum pratense	meadow horsetail							✓	✓
Equisetum sylvaticum	woodland horsetail			✓		✓	✓		✓
Fragaria virginiana	wild strawberry				✓				
Galium triflorum	sweet-scented bedstraw				✓				
Lathyrus ochroleucus	cream-colored vetchling				✓				
Lycopodium annotinum	stiff club-moss			✓					
Maianthemum canadense	wild lily-of-the-valley	✓	✓		✓				
Mertensia paniculata	tall lungwort				✓	✓		✓	
Mitella nuda	bishop's-cap				✓	✓		✓	
Petasites frigidus var. palmatus	palmate-leaved coltsfoot				✓				
Pyrola asarifolia	common pink wintergreen			✓	✓				
Grass Stratum									
Calamagrostis canadensis	bluejoint		✓		✓	✓		✓	✓
Leymus innovatus	hairy wild rye		✓		✓				
Moss Stratum									
Hylocomium splendens	stair-step moss		✓	✓	✓		✓	✓	✓
Pleurozium schreberi	big red stem/Schreber	✓	✓	✓			✓	✓	✓
Polytrichum piliferum	awned hair-cap	✓							
Ptilium crista-castrensis	knight's plume moss			✓	✓		✓	✓	✓
Sphagnum spp.	peat moss						✓		
Lichen Stratum									
Cladina mitis	green/yellow reindeer lichen	✓	✓	✓			✓		
Cladina rangiferina	grey reindeer lichen	✓	✓	✓			✓		
Cladina stellaris	northern/star reindeer lichen	✓	✓	✓			✓		
Cladonia gracilis	slender cup lichen	✓					✓		
		15	30	26	44	36	17	35	15

denotes species for which fact sheets are available in Appendix F

✓ denotes species presence in the ecosite

Table 3-1 Summary of characteristic plant species for uplands ecosites and site types

Scientific name	Common name	Ecosite / Site Type							
		a	b	c	d	e	g	f	h
		Dry		Moist Poor	Moist Rich		Wet Poor	Wet Rich	
Tree Stratum									
Abies balsamea	balsam fir				✓	✓		✓	
Betula papyrifera	white birch		✓		✓	✓		✓	
Picea glauca	white spruce		✓		✓	✓		✓	✓
Picea mariana	black spruce			✓	✓		✓		✓
Pinus banksiana	jack pine	✓	✓	✓			✓		
Populus balsamifera	balsam poplar				✓	✓		✓	
Populus tremuloides	aspen		✓		✓	✓		✓	
Shrub Stratum									
Alnus viridis	green alder	✓	✓	✓	✓	✓		✓	
Alnus incana spp. tenuifolia	river alder					✓			
Amelanchier alnifolia	saskatoon		✓		✓	✓			
Aralia nudicaulis	wild sarsaparilla		✓		✓	✓		✓	
Arctostaphylos uva-ursi	common bearberry	✓	✓						
Cornus stolonifera	red-osier dogwood					✓		✓	
Corylus cornuta	beaked hazelnut				✓				
Empetrum nigrum	crowberry			✓					
Hudsonia tomentosa	sand heather	✓							
Ledum groenlandicum	common Labrador tea	✓		✓	✓		✓		✓
Linnaea borealis	twinflower	✓	✓	✓	✓	✓	✓	✓	✓
Lonicera involucrata	bracted honeysuckle					✓			
Ribes americanum	wild black currant				✓	✓		✓	
Ribes glandulosum	skunk currant					✓		✓	
Ribes hudsonianum	northern blackcurrant					✓		✓	
Ribes lacustre	bristly black currant				✓	✓		✓	
Ribes oxyacanthoides	northern gooseberry				✓	✓		✓	
Ribes triste	wild red currant				✓				
Rosa acicularis	prickly rose		✓	✓	✓	✓	✓	✓	✓
Rubus idaeus	wild red raspberry				✓	✓		✓	
Rubus pubescens	dewberry				✓	✓		✓	
Salix athabascensis	Athabasca willow		✓	✓	✓	✓		✓	
Salix bebbiana	beaked willow		✓	✓	✓	✓		✓	
Salix discolor	pussy willow		✓	✓	✓	✓		✓	
Salix drummondiana	Drummond's willow		✓	✓	✓	✓		✓	
Salix glauca	smooth willow		✓	✓	✓	✓		✓	
Salix myrtillifolia	myrtle-leaved willow		✓	✓	✓	✓		✓	
Salix scouleriana	Scouler's willow		✓	✓	✓	✓		✓	
Salix spp.	willow					✓		✓	✓
Shepherdia canadensis	Canada buffaloberry		✓		✓				
Symphoricarpos albus	snowberry				✓				
Vaccinium myrtilloides	common blueberry	✓	✓	✓			✓		
Vaccinium vitis-idaea	bog cranberry	✓	✓	✓			✓		✓
Viburnum edule	low-bush cranberry				✓	✓		✓	

Scientific name	Common name	Ecosite / Site Type							
		a	b	c	d	e	g	f	h
		Dry		Moist Poor	Moist Rich		Wet Poor	Wet Rich	
Forb Stratum									
Aster conspicuus	showy aster				✓				
Cornus canadensis	bunchberry		✓	✓	✓	✓	✓	✓	✓
Epilobium angustifolium	common fireweed		✓		✓	✓			
Equisetum arvense	common horsetail					✓		✓	✓
Equisetum pratense	meadow horsetail							✓	✓
Equisetum sylvaticum	woodland horsetail			✓		✓	✓		✓
Fragaria virginiana	wild strawberry				✓				
Galium triflorum	sweet-scented bedstraw				✓				
Lathyrus ochroleucus	cream-colored vetchling				✓				
Lycopodium annotinum	stiff club-moss			✓					
Maianthemum canadense	wild lily-of-the-valley	✓	✓		✓				
Mertensia paniculata	tall lungwort				✓	✓		✓	
Mitella nuda	bishop's-cap				✓	✓		✓	
Petasites frigidus var. palmatus	palmate-leaved coltsfoot				✓				
Pyrola asarifolia	common pink wintergreen			✓	✓				
Grass Stratum									
Calamagrostis canadensis	bluejoint		✓		✓	✓		✓	✓
Leymus innovatus	hairy wild rye		✓		✓				
Moss Stratum									
Hylocomium splendens	stair-step moss		✓	✓	✓		✓	✓	✓
Pleurozium schreberi	big red stem/Schreber	✓	✓	✓			✓	✓	✓
Polytrichum piliferum	awned hair-cap	✓							
Ptilium crista-castrensis	knight's plume moss			✓	✓		✓	✓	✓
Sphagnum spp.	peat moss						✓		
Lichen Stratum									
Cladina mitis	green/yellow reindeer lichen	✓	✓	✓			✓		
Cladina rangiferina	grey reindeer lichen	✓	✓	✓			✓		
Cladina stellaris	northern/star reindeer lichen	✓	✓	✓			✓		
Cladonia gracilis	slender cup lichen	✓					✓		
		15	30	26	44	36	17	35	15

denotes species for which fact sheets are available in Appendix F

✓ denotes species presence in the ecosite

4. End Land-use and Target Declaration, and Species Selection and Establishment

This section provides detailed guidance on declaration of end land-use and revegetation targets, and recommended actions to meet those targets. This guidance corresponds to Steps 4-8 in the ecosite/site type approach described in Section 2 (Figure 2-1) and Steps 2-6 in the end land-use approach (Figure 2-2). Required input for this Section, when following the ecosite/site type approach, includes estimated SMR and SNR (using the LCCS; Section 2, Step 2 in Figure 2-1) and Soil Salinity Limitations (using the LCCS; Section 2, Step 3 in Figure 2-1). There are no required inputs when following the end land-use approach.

It is the intention of this manual that all revegetation planning will be guided by a "declaration" of revegetation intent. This declaration would include the target end land-use, ecosite/site type, and crown closure class. Further detail on this declaration is provided in the sections below.

4.1. End Land-use Determination

The previous version of the Revegetation Manual referenced work by the Oil Sands Mining End Land-use Committee (1998) to define allowable end land-use options for terrestrial ecosites (see Section 2.2 and Figure 2.3 in that manual, which is reproduced as Figure 4-1 on the following page).

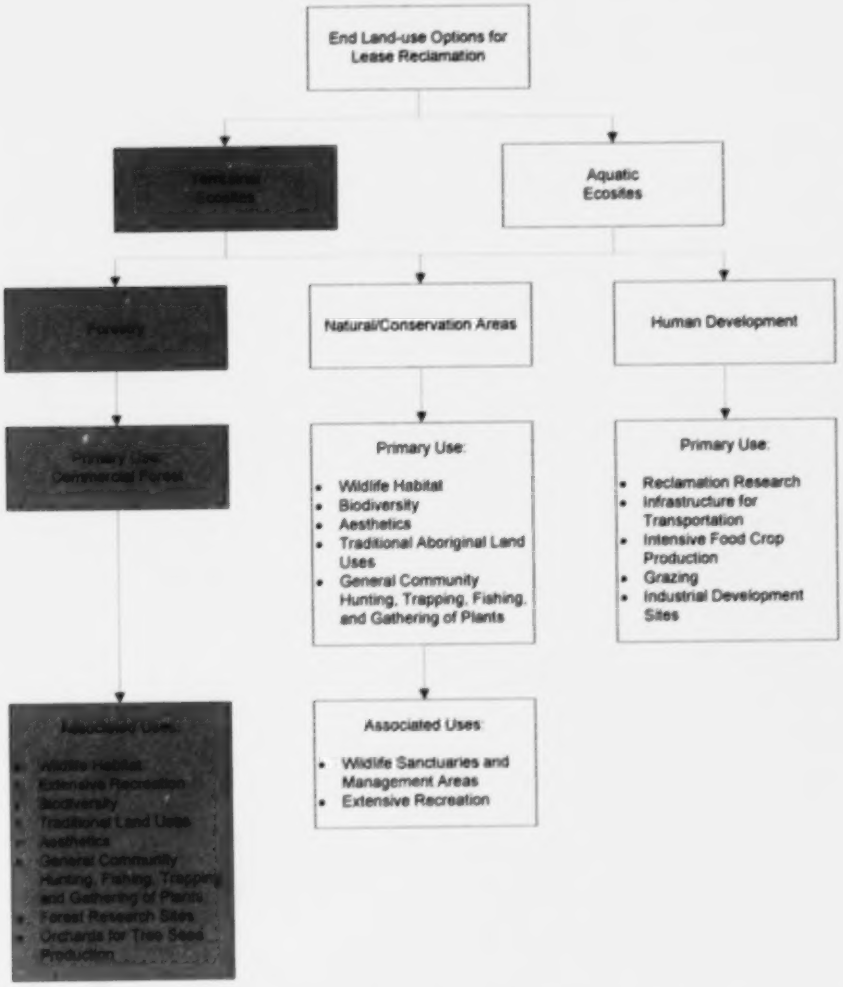

End Land-use Options for Lease Reclamation
Terrestrial Ecosites
Aquatic Ecosites
Forestry
Natural/Conservation Areas
Human Development
Primary Use: Commercial Forest
Primary Use:
Wildlife Habitat
Biodiversity
Aesthetics
Traditional Aboriginal Land Uses
General Community Hunting, Trapping, Fishing, and Gathering of Plants
Primary Use:
Reclamation Research
Infrastructure for Transportation
Intensive Food Crop Production
Grazing
Industrial Development Sites
Associated Uses:
Wildlife Habitat
Extensive Recreation
Biodiversity
Traditional Land Uses
Aesthetics
General Community Hunting, Fishing, Trapping and Gathering of Plants
Forest Research Sites
Orchards for Tree Seed Production
Associated Uses:
Wildlife Sanctuaries and Management Areas
Extensive Recreation

Figure 4-1 **End land-use options recommended by the Oil Sands Mining End Land-use Committee (shaded boxes represent the land-use objectives addressed in this document)**

Of the defined allowable options, the Oil Sands Vegetation Reclamation Committee chose to look at two acceptable objectives within a forest ecosystem: the primary use of commercial forest for timber production, and the associated use of wildlife habitat, although the 1998 manual acknowledged that other land-uses (such as traditional use and recreation) could be considered at a later date. This updated version of the manual considers four primary end land-uses:

1. Commercial Forest,
2. Wildlife Habitat,
3. Traditional Use, and
4. Recreation.

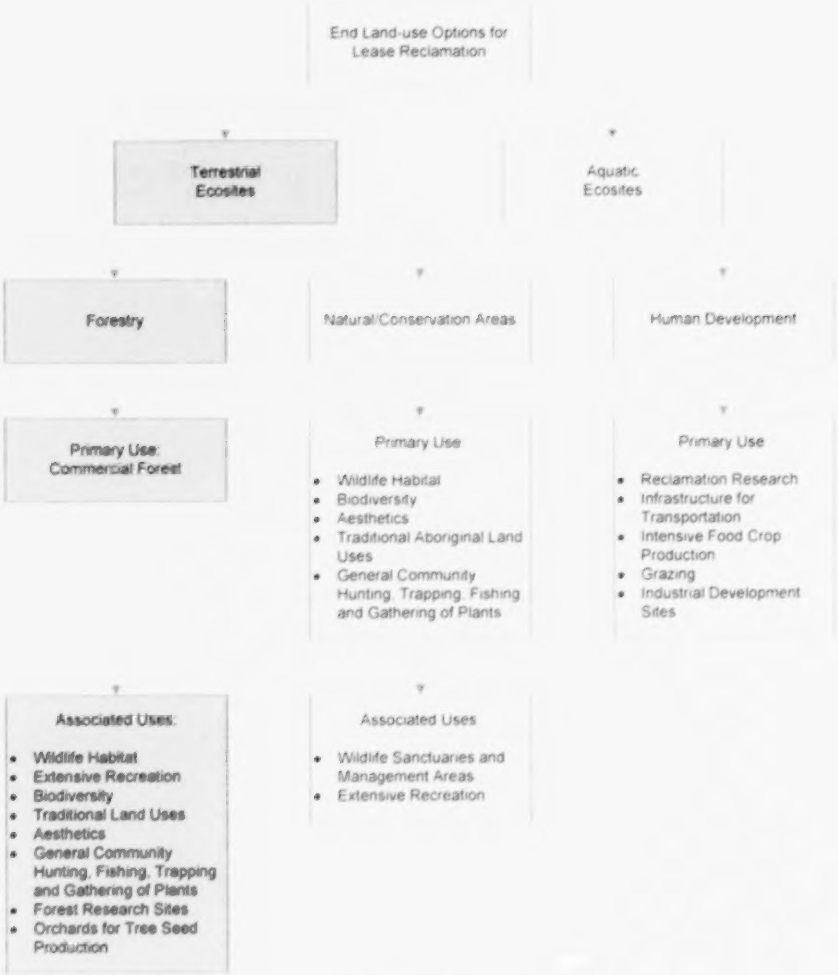

End Land-use Options for Lease Reclamation
Terrestrial Ecosites
Aquatic Ecosites
Forestry
Natural/Conservation Areas
Human Development
Primary Use: Commercial Forest
Primary Use
• Wildlife Habitat
• Biodiversity
• Aesthetics
• Traditional Aboriginal Land Uses
• General Community Hunting, Trapping, Fishing and Gathering of Plants
Primary Use
• Reclamation Research
• Infrastructure for Transportation
• Intensive Food Crop Production
• Grazing
• Industrial Development Sites
Associated Uses:
• Wildlife Habitat
• Extensive Recreation
• Biodiversity
• Traditional Land Uses
• Aesthetics
• General Community Hunting, Fishing, Trapping and Gathering of Plants
• Forest Research Sites
• Orchards for Tree Seed Production
Associated Uses
• Wildlife Sanctuaries and Management Areas
• Extensive Recreation

Figure 4-1 **End land-use options recommended by the Oil Sands Mining End Land-use Committee (shaded boxes represent the land-use objectives addressed in this document)**

Of the defined allowable options, the Oil Sands Vegetation Reclamation Committee chose to look at two acceptable objectives within a forest ecosystem: the primary use of commercial forest for timber production, and the associated use of wildlife habitat, although the 1998 manual acknowledged that other land-uses (such as traditional use and recreation) could be considered at a later date. This updated version of the manual considers four primary end land-uses:

1. Commercial Forest,
2. Wildlife Habitat,
3. Traditional Use, and
4. Recreation

The latter three end land-uses can collectively be described as non-commercial forest, and are categorized in that way in Figures 2-1 and 2-2. The decision to include four primary end land-use options, rather than the one included in the 1998 manual, was made for two reasons:

1. Reclamation to commercial forest is limited by a number of factors, such as reclaimed soil conditions, overstory planting densities, and operability constraints. Thus, not all reclaimed upland areas will be capable of supporting commercial forest.
2. It is assumed that it will be desirable to create vegetation conditions for non-commercial forest that will make reclamation of commercially viable forest attributes unachievable. For instance, it may be desirable to create sparsely stocked stands for wildlife or traditional use – although these stands might be entirely successful forest reclamation, they might not be consistent with commercial yield requirements.

Despite the inclusion of a number of primary end land-use alternatives, it is expected that the majority of reclaimed forest ecosystems will be capable of supporting multiple end land-uses simultaneously. For this reason, the foundation of revegetation planning in this manual is the ecosite/site type, as all reclaimed forest will be targeted towards and evaluated against vegetation characteristics of a given edatopic position(s). The end land-use decision simply introduces an additional layer of constraints and guidance, as summarized in Table 4-1.

Table 4-1 Constraints and actions for end land-use determination

		Constraints	Actions
End Land-use	Commercial Forest	• Anticipated topsoil salinity must be ≤ 2 dS/m (from LCCS) • Declared crown closure class must be C/D (see Section 4.3.2) • Operability constraints (see Section 4.2)	• Follow appropriate guidance for selected ecosite and crown closure declaration
	Wildlife Habitat	• Species-specific	• Follow appropriate guidance for selected ecosite and crown closure declaration • Refer to Appendix D for additional guidance
	Traditional Use	• Activity-specific	• Follow appropriate guidance for selected ecosite and crown closure declaration • Refer to Appendix E for additional guidance
	Recreation	• Activity-specific	• Follow appropriate guidance for selected ecosite and crown closure declaration • Refer to Section 4.1.1 for additional guidance

4.1.1. Recreation End Land-use

Although this manual recognizes recreation as a potential and valid end land-use, it is not a use that is principally ecologically driven. Reclamation design for this end land-use will be specific to intended activities. Thus, the majority of the principles and guidelines presented in this manual may not apply. For this reason, no further guidance on recreation end land-uses is provided in this document.

4.2. Commercial Forest Operability Constraints

The potential to designate a stand as commercial forest is constrained by operability rules designed to safeguard ecosystems against degradation and to maintain and protect the range of values and services these ecosystems provide. Section 5 of the Alberta *Forests Act* and Section 100 (b) of the Timber Management Regulation detail many of these operability rules. A comprehensive listing can be found in the *Alberta Timber Harvest and Operating Ground Rules Handbook* (Alberta Sustainable Resource Development 2008) and in the *Pre-Harvest Assessment Handbook & Forest Site Interpretation and Silvicultural Prescription Guide for Alberta* (Alberta Environment 2001). A summary of the characteristics necessary to achieve a commercial forest as a primary end land-use designation is provided in Table 4-2. Stands with merchantable timber that will not satisfy these requirements, as well as stands comprised of non-merchantable timber, must declare a primary end land-use other than commercial forest.

Table 4-2 Characteristic features that designate a reclaimed area as suitable for commercial forest

Design Element	Commercial Forest
Slope	≤ 45% (≤ 20% on tailings sand slopes)
Minimum area to be reclaimed	≥ 4 ha
Minimum width of reclaimed area	≥ 40 m
Distance to large permanent watercourse[a]	≥ 60 m from HWM[b]
Distance to small permanent watercourse[c]	≥ 30 m from HWM
Lakes[d] with little or no recreation, waterfowl or sport fishing potential	≥ 100 m from HWM on lakes > 16 ha
Lakes[d] with recreation, waterfowl, or sport fishing potential	≥ 100 m from HWM on lakes > 4 ha
Water source areas, and areas subject to normal seasonal flooding[e]	≥ 20 m from water source

[a] Examples include major streams or rivers, well-defined flood plains, and valleys usually exceeding 400m in width.

[b] High water mark: water levels corresponding to the top of an unvegetated channel or lake shore.

[c] Examples include permanent streams, small valleys; may have bench (floodplain) development.

[d] Large water collection areas permanently filled with water.

[e] Examples include areas with saturated soils, surface flow, or seepage.

4.3. Declaration of Target Ecosite and Crown Closure Class

Determination of targets for ecosite/site type and crown closure class defines the majority of revegetation actions for all upland sites and end land-uses. The parameters are addressed below.

4.3.1. Declaration of Target Ecosite

One of the principles of the Revegetation Manual is that the user will provide a declaration of intent, and plan accordingly for, a selected ecosite, but be evaluated with reference to the associated site type (more discussion of revegetation monitoring and evaluation is provided in Section 5). The rationale for this distinction is that it will be helpful to conduct planning based on a well defined and well understood ecological unit (the ecosite), but that the evaluation target should incorporate the uncertainty of early vegetation trajectories and an estimation of SMR and SNR on reclaimed sites. Note that the target for overstory species selection and planting density is for the most part based on site type, not ecosite, due to insufficient data on which to base ecosite guidelines (Section 4.4).

In the ecosite/site type approach, the declaration of target ecosite is based on the soil characteristics of the designed or existing capping treatment (see Figure 2-1 and corresponding Steps 2 and 4 in Section 2), and the resulting position of the site to be reclaimed on the Edatopic Grid (Section 3). In order to estimate edatopic position, the user requires an estimate of both SMR and SNR. This estimate is calculated using the LCCS, and should be available for designed or existing capping treatments. For reference, SMR is addressed in Section 4.2, and summarized in Table 9 of the LCCS (Alberta Environment 2006, pp. 37-38). SNR is addressed in Section 4.3 and summarized in Table 10 of the LCCS (Alberta Environment 2006, p. 41). The LCCS process will generate an estimated SMR from xeric to hydric, and an estimated SNR from poor to rich – these estimates are then used on the edatopic grid in this manual (Section 3) to identify the associated ecosite and site type. For example, a mesic SMR and medium SNR would indicate a d ecosite – in this case the user would declare the site a d ecosite for revegetation planning purposes, and be evaluated with reference to the Moist Rich site type. Where estimated edatopic positions indicate multiple possible ecosites and site types, the user will declare which of the potential options is the target for revegetation planning, based on revegetation goals. For example, a submesic SMR and poor (B) nutrient regime could indicate either a c ecosite (Moist Poor site type), or a b ecosite (Dry site type) – in this case a decision would be made by the revegetation planner as to the actual target.

In the end land-use approach, the declaration of target ecosite is based on desired vegetation community characteristics consistent with the selected end land-use. Guidance on appropriate ecosites and vegetation characteristics for specific end land-uses is provided in Appendices D (for wildlife habitat) and E (for traditional use), and below in Section 4.4 (for commercial forest).

4.3.2. Declaration of Crown Closure Target

Crown closure (also known as canopy cover, crown cover, or canopy closure) refers to the percentage of area covered by a vertical projection of tree crowns onto the ground. In this respect, it can be considered as an index of:

1. The relative dominance of trees on site;
2. Stand density; and/or
3. Potential volume.

Table 4-3 shows four classes of crown closure and their interpretive codes as defined under the Alberta Vegetation Inventory Standards Manual (AVI 1991).

Table 4-3 **Crown closure classes and their associated vegetation inventory codes**

Crown Closure (%)	Code	Interpretation
6 - 30	A	Very sparse to sparse cover
31 - 50	B	Low cover
51 - 70	C	Medium cover
71 - 100	D	Dense to very dense cover

When crown closure is high, trees represent the dominant vegetation since canopy light interception is high and below-canopy light levels are insufficient to support a vigorous undergrowth. These conditions are characteristic of commercial forest stands and they typically occur on submesic to subhygric moisture regimes and medium to rich nutrient regimes (see Section 3). Low crown closure can also occur under favourable site conditions and is usually indicative of a highly competitive understory that has succeeded in limiting tree establishment and growth by restricting access to site resources (light, water, and nutrients). These communities may contain a broad diversity of understory plant species and thus have high biodiversity and value for wildlife. On dry, nutritionally poor sites, or sites that are poorly drained, the harsh abiotic conditions limit tree productivity and canopy closure is typically low. Trees may still represent the dominant vegetation type (examples include jack pine-dominated stands on the dry, sandy soils of an a ecosite, and jack pine/black spruce stands on poorly drained organic soils in a g ecosite; see Figure 4.13, Beckingham and Archibald 1996), though other minor vegetation can be abundant.

For purposes of reclamation planning and revegetation declaration, the four classes presented above have been aggregated into two: A/B (6-50% crown closure), and C/D (> 50%), and are intended to be interpreted as target classes at stand maturity. The user will declare a crown closure target of class A/B (open stands, crown closure of 6-50% at maturity) or C/D (closed stands, crown closure of >50% at maturity). Because commercial forests require fully stocked stands, identification of commercial forest as the primary end land-use precludes selection of open crown closure classes. Crown closure targets for commercial forest are constrained to classes C/D. Selection of crown closure targets for non-commercial forest end land-uses is unconstrained. Open stands may be selected where reclamation objectives require a sparse overstory with higher understory light levels (e.g., production of understory species for wildlife habitat or traditional use).

4.3.3. Summary of Declaration

A summary of the declaration parameters and options is presented in Table 4-4, below.

Table 4-4 **Declaration/planning form**

End Land-use	Ecosite	Crown Closure
Commercial Forest	a-h	C/D
Wildlife Habitat	a-h	A/B or C/D
Traditional Use		
Recreation		

4.4. Selecting Overstory Species and Establishment Densities

Guidance on overstory species selection and establishment densities is presented in a series of tables (Tables 4-5 to 4-14), which are organized by site type. Tables are separated by target crown closure class (A/B versus C/D), and are stratified by stand type or desired overstory species. Note that these tables indicate appropriate species for establishment on given site types. The sequence of development of information presented in the tables was as follows:

1. A mean density for natural, mature stands was determined for site type/crown closure class/overstory species combinations from available plot data or AVI interpretive rules.
2. A range of mature stand densities was derived by using mean values +/- 20%.
3. The forest growth-and-yield model GYPSY was used to determine densities at a stand age of 8 years that would produce the above target mature stand conditions.
4. GYPSY model results were reviewed and adjusted based on professional opinion to increase applicability to forest regeneration on reclamation sites (e.g., high juvenile aspen densities produced by GYPSY were reduced to account for seed-origin—container-seedling—as opposed to sucker-origin stock). In some cases (e.g., aspen), these adjustments were substantial; in others, they consisted simply of rounding numbers to the nearest 50.
5. Minimum year-8 densities for the C/D crown class (the fully stocked class, allowing declaration of a commercial forest end land-use target) were set to approximately 1200 stems per hectare to allow achievement of an 80% stocking standard, consistent with current Alberta Regeneration Standards.

6. GYPSY was then run "forward" using adjusted initial densities to provide final projected mature stand densities.
7. Planting densities were determined using an arbitrary assumed value of 10% mortality between planting and age 8 years.

Additional information in the overstory guidance tables includes:

1. Square-spacing distance (in metres) that corresponds to the listed planting densities.
2. Assumed mature stand ages used in GYPSY model runs.

Additional notes on information included in the overstory tables are as follows:

- Although the information provided on expected density ranges at year 8 is intended primarily to document model assumptions and the link between planting densities and projected mature-stand conditions, these ranges could be used to inform development of revised Regeneration Standards for oil sands mine reclamation.
- It is important to emphasize that the planting densities provided in the following tables assume a uniform 10% mortality rate from 0-8 years – if operators believe that mortality on a given site is likely to be less or more than this value, planting densities can be adjusted accordingly. This mortality assumption will be updated/validated through future data collection and analysis on reclaimed sites.
- Note also that densities are based on the stated average site index model input value. In general, more productive sites (with higher site indices) will experience higher mortality rates (due to increased competition-induced mortality), while less productive sites will experience lower mortality. Planting densities may thus be adjusted accordingly to meet different site index/site productivity expectations.
- For commercial forest end land-uses (C/D crown classes), minimum planting densities were determined with reference to the objective of obtaining 80% stocking at year 8 following planting, as required by the current Alberta Regeneration Standards. Achievement of this objective requires a stand density of approximately 1200 stems per hectare at year 8, so planting densities were correspondingly adjusted to meet this year-8 target, assuming 10% mortality between planting and the year 8 assessment. It is critical to note that the minimum planting densities for crown class C/D in the following tables will only meet the 80% stocking standard where mortality does not exceed 10% in the first 8 years. Where operators anticipate mortality in excess of this value, planting densities should be increased correspondingly.
- Table 3-1, the Summary of Characteristic Plant Species (see Section 3), indicates that two deciduous species in addition to aspen may be present in upland forest types in the region. White birch (Bw) is present on Dry, Moist Rich, and Wet Rich site types, while balsam polar (Pb) is present on Moist Rich and Wet Rich site types. However, at this time, specific capability for these trees does not exist in the GYPSY model, and they are assumed to behave similarly to aspen in terms of stand density development. Therefore, where applicable (e.g., in the site types noted directly above), these species may be substituted for aspen.

The development of the planting densities presented in Tables 4-5 through 4-14 were guided by the five caveats listed below:

1. The 10% mortality rate used in the planting density calculations does not account for ingress.
2. If there is no ecosite phase in Beckingham and Archibald (1996) for a stand type in the corresponding site type, then the stand type was not included in the planting density table; if there was some operational value in keeping the stand type for that site type, the stand type was retained.
3. Aw mature stand density predictions calculated by GYPSY were manually modified to predict about 15-25% more aspen at rotation age based on the assumption that planted Aw will have higher mature stand densities than GYPSY predicts using sucker origin data because mortality rates in planted aspen will likely be much lower than those in natural sucker-origin aspen stands.
4. On Wet Rich site types, it is more likely that Pb will be planted than Aw; the planting density estimates calculated by GYPSY for Aw were assumed to be the same for Pb. It is possible that overall maximum planting density for Pb could be lower than presented for aspen, due to the resilience of Pb, but insufficient information exists at this time to state this with confidence.
5. In the application of Tables 4-5 to 4-14, with specific reference to the A/B crown closure tables, where conifer planting densities are lower; careful consideration to understory species selection is recommended to account for interspecific competitive relationships (e.g., excessive grass covers may inhibit tree establishment and growth).

Refer to the technical report for detailed descriptions of the development of the planting densities (Timberline Natural Resources Group Ltd. 2009).

4.4.1. Dry Site Type

The planting densities for the A/B crown closure (Table 4-5) and C/D crown closure (Table 4-6) on the Dry site type are provided for the following stand types:

- Pure jack pine (Pj);
- Jack pine leading aspen (Pj-Aw);
- Aspen leading white spruce (Aw-Sw);
- White spruce leading aspen (Sw-Aw);
- Jack pine leading white spruce (Pj-Sw); and
- Pure aspen (Aw).

Note that white birch may be substituted for aspen in these stands.

Table 4-5 Overstory species selection and planting densities for dry site type, A/B crown closure

Stand Type	**Species**	**Planting Density**		**Survey @ 8 years**		**Mature Stand**			**Species Percent**		**Square Spacing (m)**	
				Density		**Density**		**Stand Age (years)**				
		Min	**Max**	**Min**	**Max**	**Min**	**Max**					
Pj	Pj	600	1,400	540	1,260	458	718	80	100%	100%		
Total		***600***	***1,400***	***540***	***1,260***	***458***	***718***		***100%***	***100%***	***4.1***	***2.7***
Aw	Aw	1,000	2,500	900	2,250	446	669	60	100%	100%		
Total		***1,000***	***2,500***	***900***	***2,250***	***446***	***669***		***100%***	***100%***	***3.2***	***2.0***
Pj-Aw	Pj	400	800	360	720	335	525	80	63%	66%		
	Aw	300	600	270	540	199	268	80	37%	34%		
Total		***700***	***1,400***	***630***	***1,260***	***534***	***793***		***100%***	***100%***	***3.8***	***2.7***
Aw-Sw	Aw	800	1,800	720	1,620	402	580	60	69%	63%		
	Sw	200	400	180	360	177	336	60	31%	37%		
Total		***1,000***	***2,200***	***900***	***1,980***	***578***	***916***		***100%***	***100%***	***3.2***	***2.1***
Sw-Aw	Sw	450	1,000	405	900	352	606	90	68%	75%		
	Aw	250	400	225	360	169	207	90	32%	25%		
Total		***700***	***1,400***	***630***	***1,260***	***521***	***812***		***100%***	***100%***	***3.8***	***2.7***
Pj-Sw	Pj	350	800	315	720	300	527	80	57%	51%		
	Sw	250	600	225	540	222	505	80	43%	49%		
Total		***600***	***1,400***	***540***	***1,260***	***521***	***1,032***		***100%***	***100%***	***4.1***	***2.7***

Table 4-6 Overstory species selection and planting densities for dry site type, C/D crown closure

Stand Type	Species	Planting Density		Survey @ 8 years		Mature Stand			Species Percent		Square Spacing (m)	
				Density		Density		Stand Age (years)				
		Min	Max	Min	Max	Min	Max					
Pj	Pj	1,400	2,000	1,260	1,800	718	836	80	100%	100%		
Total		***1,400***	***2,000***	***1,260***	***1,800***	***718***	***836***		***100%***	***100%***	***2.7***	***2.2***
Aw	Aw	2,500	5,000	2,250	4,500	669	905	60	100%	100%		
Total		***2,500***	***5,000***	***2,250***	***4,500***	***669***	***905***		***100%***	***100%***	***2.0***	***1.4***
Pj-Aw	Pj	800	1,500	720	1,350	525	679	80	66%	68%		
	Aw	600	1,000	540	900	268	319	80	34%	32%		
Total		***1,400***	***2,500***	***1,260***	***2,250***	***793***	***997***		***100%***	***100%***	***2.7***	***2.0***
Aw-Sw	Aw	1,800	4,000	1,620	3,600	580	820	60	63%	64%		
	Sw	400	600	360	540	336	470	60	37%	36%		
Total		***2,200***	***4,600***	***1,980***	***4,140***	***916***	***1,290***		***100%***	***100%***	***2.1***	***1.5***
Sw-Aw	Sw	1,000	1,800	900	1,620	606	816	90	75%	77%		
	Aw	400	700	360	630	207	245	90	25%	23%		
Total		***1,400***	***2,500***	***1,260***	***2,250***	***812***	***1,061***		***100%***	***100%***	***2.7***	***2.0***
Pj-Sw	Pj	800	1,200	720	1,080	527	625	80	51%	49%		
	Sw	600	800	540	720	505	650	80	49%	51%		
Total		***1,400***	***2,000***	***1,260***	***1,800***	***1,032***	***1,275***		***100%***	***100%***	***2.7***	***2.2***

4.4.2. Moist Poor Site Type

The planting densities for the A/B crown closure (Table 4-7) and C/D crown closure (Table 4-8) on the Moist Poor site type are provided for jack pine leading black spruce (Pj-Sb) stand types.

Table 4-7 Overstory species selection and planting densities for moist poor site type, A/B crown closure

Stand Type	Species	Planting Density		Survey @ 8 years		Mature Stand			Species Percent		Square Spacing (m)	
				Density		Density		Stand Age (years)				
		Min	Max	Min	Max	Min	Max					
Pj-Sb	Pj	700	1,000	630	900	511	621	80	70%	68%		
	Sb	300	400	270	360	217	290	80	30%	32%		
Total		***1,000***	***1,400***	***900***	***1,260***	***729***	***911***		***100%***	***100%***	***3.2***	***2.7***

Table 4-8 Overstory species selection and planting densities for moist poor site type, C/D crown closure

Stand Type	Species	Planting Density		Survey @ 8 years		Mature Stand			Species Percent		Square Spacing (m)	
				Density		Density		Stand Age (years)				
		Min	Max	Min	Max	Min	Max					
Pj-Sb	Pj	1,000	1,500	900	1,350	621	744	80	68%	67%		
	Sb	400	500	360	450	290	361	80	32%	33%		
Total		***1,400***	***2,000***	***1,260***	***1,800***	***911***	***1,105***		***100%***	***100%***	***2.7***	***2.2***

4.4.3. Moist Rich Site Type

The planting densities for the A/B crown closure (Table 4-9) and C/D crown closure (Table 4-10) on the Moist Rich site type are provided for the following stand types:

- Aspen leading white spruce (Aw-Sw);
- White spruce leading aspen (Sw-Aw);
- Pure aspen (Aw); and
- Pure white spruce (Sw).

Note that white birch or balsam poplar may be substituted for aspen in these stands.

Table 4-9 Overstory species selection and planting densities for moist rich site type, A/B crown closure

Stand Type	Species	Planting Density		Survey @ 8 years		Mature Stand			Species Percent		Square Spacing (m)	
				Density		Density		Stand Age (years)				
		Min	Max	Min	Max	Min	Max					
Aw-Sw	Aw	800	2,100	720	1,890	400	617	60	69%	65%		
	Sw	200	400	180	360	176	330	60	31%	35%		
Total		***1,000***	***2,500***	***900***	***2,250***	***576***	***947***		***100%***	***100%***	***3.2***	***2.0***
Sw-Aw	Sw	450	1,000	405	900	346	585	90	69%	76%		
	Aw	250	400	225	360	158	188	90	31%	24%		
Total		***700***	***1,400***	***630***	***1,260***	***505***	***773***		***100%***	***100%***	***3.8***	***2.7***
Aw	Aw	1,000	2,500	900	2,250	423	627	60	100%	100%		
Total		***1,000***	***2,500***	***900***	***2,250***	***423***	***627***		***100%***	***100%***	***3.2***	***2.0***
Sw	Sw	500	1,400	450	1,260	422	975	90	100%	100%		
Total		***500***	***1,400***	***450***	***1,260***	***422***	***975***		***100%***	***100%***	***4.5***	***2.7***

Table 4-10 Overstory species selection and planting densities for moist rich site type, C/D crown closure

Stand Type	Species	Planting Density		Survey @ 8 years		Mature Stand			Species Percent		Square Spacing (m)	
				Density		Density		Stand Age (years)				
		Min	Max	Min	Max	Min	Max					
Aw-Sw	Aw	2,100	4,300	1,890	3,870	617	842	60	65%	62%		
	Sw	400	700	360	630	330	513	60	35%	38%		
Total		***2,500***	***5,000***	***2,250***	***4,500***	***947***	***1,354***		***100%***	***100%***	***2.0***	***1.4***
Sw-Aw	Sw	1,000	1,800	900	1,620	585	780	90	76%	78%		
	Aw	400	700	360	630	188	220	90	24%	22%		
Total		***1,400***	***2,500***	***1,260***	***2,250***	***773***	***1,000***		***100%***	***100%***	***2.7***	***2.0***
Aw	Aw	2,500	5,000	2,250	4,500	627	845	60	100%	100%		
Total		***2,500***	***5,000***	***2,250***	***4,500***	***627***	***845***		***100%***	***100%***	***2.0***	***1.4***
Sw	Sw	1,400	2,000	1,260	1,800	975	1,242	90	100%	100%		
Total		***1,400***	***2,000***	***1,260***	***1,800***	***975***	***1,242***		***100%***	***100%***	***2.7***	***2.2***

4.4.4. Wet Rich Site Type

The planting densities for the A/B crown closure (Table 4-11) and C/D crown closure (Table 4-12) on the Wet Rich site type are provided for the following stand types:

- Aspen leading white spruce (Aw-Sw);
- White spruce leading aspen (Sw-Aw);
- Pure aspen (Aw); and
- Pure white spruce (Sw).

Note that white birch or balsam poplar may be substituted for aspen in these stands.

Table 4-11 Overstory species selection and planting densities for wet rich site type, A/B crown closure

Stand Type	Species	Planting Density		Survey @ 8 years		Mature Stand			Species Percent		Square Spacing (m)	
				Density		Density		Stand Age (years)				
		Min	Max	Min	Max	Min	Max					
Aw-Sw	Aw	800	2,100	720	1,890	438	695	60	71%	67%		
	Sw	200	400	180	360	177	339	60	29%	33%		
Total		***1,000***	***2,500***	***900***	***2,250***	***615***	***1,035***		***100%***	***100%***	***3.2***	***2.0***
Sw-Aw	Sw	450	1,000	405	900	361	641	90	67%	74%		
	Aw	250	400	225	360	181	229	90	33%	26%		
Total		***700***	***1,400***	***630***	***1,260***	***542***	***870***		***100%***	***100%***	***3.8***	***2.7***
Sw-Sb	Sw	250	600	225	540	222	506	90	48%	48%		
	Sb	350	800	315	720	240	537	90	52%	52%		
Total		***600***	***1,400***	***540***	***1,260***	***462***	***1,043***		***100%***	***100%***	***4.1***	***2.7***
Aw	Aw	1,000	2,500	900	2,250	491	752	60	100%	100%		
Total		***1,000***	***2,500***	***900***	***2,250***	***491***	***752***		***100%***	***100%***	***3.2***	***2.0***
Sw	Sw	500	1,400	450	1,260	428	1,024	90	100%	100%		
Total		***500***	***1,400***	***450***	***1,260***	***428***	***1,024***		***100%***	***100%***	***4.5***	***2.7***

Table 4-12 Overstory species selection and planting densities for wet rich site type, C/D crown closure

Stand Type	Species	Planting Density		Survey @ 8 years		Mature Stand			Species Percent		Square Spacing (m)	
				Density		Density		Stand Age (years)				
		Min	Max	Min	Max	Min	Max					
Aw-Sw	Aw	2,100	4,300	1,890	3,870	695	961	60	67%	64%		
	Sw	400	700	360	630	339	544	60	33%	36%		
Total		***2,500***	***5,000***	***2,250***	***4,500***	***1,035***	***1,504***		***100%***	***100%***	***2.0***	***1.4***
Sw-Aw	Sw	1,000	1,800	900	1,620	641	882	90	74%	76%		
	Aw	400	700	360	630	229	278	90	26%	24%		
Total		***1,400***	***2,500***	***1,260***	***2,250***	***870***	***1,160***		***100%***	***100%***	***2.7***	***2.0***
Sw-Sb	Sw	600	1,100	540	990	506	848	90	48%	50%		
	Sb	800	1,300	720	1,170	537	847	90	52%	50%		
Total		***1,400***	***2,400***	***1,260***	***2,160***	***1,043***	***1,695***		***100%***	***100%***	***2.7***	***2.0***
Aw	Aw	2,500	5,000	2,250	4,500	752	1,029	60	100%	100%		
Total		***2,500***	***5,000***	***2,250***	***4,500***	***752***	***1,029***		***100%***	***100%***	***2.0***	***1.4***
Sw	Sw	1,400	2,000	1,260	1,800	1,024	1,326	90	100%	100%		
Total		***1,400***	***2,000***	***1,260***	***1,800***	***1,024***	***1,326***		***100%***	***100%***	***2.7***	***2.2***

4.4.5. Wet Poor Site Type

The planting densities for the A/B crown closure (Table 4-13) and C/D crown closure (Table 4-14) on the Wet Poor site type are provided for the following stand types:

- Black spruce leading jack pine (Sb-Pj); and
- Pure black spruce (Sb).

Table 4-13 Overstory species selection and planting densities for wet poor site type, A/B crown closure

Stand Type	Species	Planting Density		Survey @ 8 years		Mature Stand			Species Percent		Square Spacing (m)	
				Density		Density		Stand Age (years)				
		Min	Max	Min	Max	Min	Max					
Sb-Pj	Sb	450	900	405	810	266	514	110	56%	61%		
	Pj	250	500	225	450	208	326	110	44%	39%		
Total		***700***	***1,400***	***630***	***1,260***	***473***	***839***		***100%***	***100%***	***3.8***	***2.7***
Sb	Sb	700	1,400	630	1,260	406	766	110	100%	100%		
Total		***700***	***1,400***	***630***	***1,260***	***406***	***766***		***100%***	***100%***	***3.8***	***2.7***

Table 4-14 Overstory species selection and planting densities for wet poor site type, C/D crown closure

Stand Type	Species	Planting Density		Survey @ 8 years		Mature Stand			Species Percent		Square Spacing (m)	
				Density		Density		Stand Age (years)				
		Min	Max	Min	Max	Min	Max					
Sb-Pj	Sb	900	1,800	810	1,620	514	955	110	61%	72%		
	Pj	500	1,000	450	900	326	376	110	39%	28%		
Total		***1,400***	***2,800***	***1,260***	***2,520***	***839***	***1,331***		***100%***	***100%***	***2.7***	***1.9***
Sb	Sb	1,400	2,800	1,260	2,520	766	1,384	110	100%	100%		
Total		***1,400***	***2,800***	***1,260***	***2,520***	***766***	***1,384***		***100%***	***100%***	***2.7***	***1.9***

4.5. Understory Species

4.5.1. Species Selection

Appropriate understory species by target ecosite a through h are presented in Tables 4-15 to 4-22. These tables are to be used to inform species selection for establishment on reclaimed sites. The species listed in Tables 4-15 to 4-22 are derived from characteristic species lists where the species is present in a minimum of 70% of the sample plots for a given vegetation class or have a prominence value of 20 or greater (see Section 3). Total lists of species for ecosites a through h are presented in Appendix I. It is expected that these characteristic species may be established by a variety of means, including bareroot and container seedling planting, application of LFH amendment (Section 4.5.3), and potentially through direct seeding. In the application of Tables 4-15 to 4-22, consideration should be given to interspecific competitive relationships (e.g., excessive grass covers may inhibit tree establishment and growth). Further information on a portion of these species and their establishment methods is provided in the vegetation Fact Sheets in Appendix F (species with fact sheets are identified in the tables).

Table 4-15 Understory species for target ecosite a

Name	Common name
Tree Stratum	
Pinus banksiana	jack pine
Shrub Stratum	
Alnus viridis	green alder
Arctostaphylos uva-ursi	common bearberry
Hudsonia tomentosa	sand heather
Ledum groenlandicum	common Labrador tea
Linnaea borealis	twinflower
Vaccinium myrtilloides	common blueberry
Vaccinium vitis-idaea	bog cranberry
Forb Stratum	
Maianthemum canadense	wild lily-of-the-valley
Moss Stratum	
Pleurozium schreberi	big red stem/Schreber
Polytrichum piliferum	awned hair-cap
Lichen Stratum	
Cladina mitis	green/yellow reindeer lichen
Cladina rangiferina	grey reindeer lichen
Cladina stellaris	northern/star reindeer lichen
Cladonia gracilis	slender cup lichen

denotes species for which fact sheets are available in Appendix F

Table 4-16 Understory species for target ecosite b

Name	Common name
Tree Stratum	
Betula papyrifera	white birch
Picea glauca	white spruce
Pinus banksiana	jack pine
Populus tremuloides	aspen
Shrub Stratum	
Alnus viridis	green alder
Amelanchier alnifolia	saskatoon
Arctostaphylos uva-ursi	common bearberry
Linnaea borealis	twinflower
Rosa acicularis	prickly rose
Salix athabascensis	Athabasca willow
Salix bebbiana	beaked willow
Salix discolor	pussy willow
Salix drummondiana	Drummond's willow
Salix glauca	smooth willow
Salix myrtillifolia	myrtle-leaved willow
Salix scouleriana	Scouler's willow
Shepherdia canadensis	Canada buffaloberry
Vaccinium myrtilloides	common blueberry
Vaccinium vitis-idaea	bog cranberry
Forb Stratum	
Aralia nudicaulis	wild sarsaparilla
Cornus canadensis	bunchberry
Epilobium angustifolium	common fireweed
Maianthemum canadense	wild lily-of-the-valley
Grass Stratum	
Calamagrostis canadensis	bluejoint
Leymus innovatus	hairy wild rye
Moss Stratum	
Hylocomium splendens	stair-step moss
Pleurozium schreberi	big red stem/Schreber
Lichen Stratum	
Cladina mitis	green/yellow reindeer lichen
Cladina rangiferina	grey reindeer lichen
Cladina stellaris	northern/star reindeer lichen

denotes species for which fact sheets are available in Appendix F

Table 4-17 Understory species for target ecosite c

Name	Common name
Tree Stratum	
Picea mariana	black spruce
Pinus banksiana	jack pine
Shrub Stratum	
Alnus viridis	green alder
Empetrum nigrum	crowberry
Ledum groenlandicum	common Labrador tea
Linnaea borealis	twinflower
Rosa acicularis	prickly rose
Salix athabascensis	Athabasca willow
Salix bebbiana	beaked willow
Salix discolor	pussy willow
Salix drummondiana	Drummond's willow
Salix glauca	smooth willow
Salix myrtillifolia	myrtle-leaved willow
Salix scouleriana	Scouler's willow
Vaccinium myrtilloides	common blueberry
Vaccinium vitis-idaea	bog cranberry
Forb Stratum	
Cornus canadensis	bunchberry
Equisetum sylvaticum	woodland horsetail
Lycopodium annotinum	stiff club-moss
Pyrola asarifolia	common pink wintergreen
Moss Stratum	
Hylocomium splendens	stair-step moss
Pleurozium schreberi	big red stem/Schreber
Ptilium crista-castrensis	knight's plume moss
Lichen Stratum	
Cladina mitis	green/yellow reindeer lichen
Cladina rangiferina	grey reindeer lichen
Cladina stellaris	northern/star reindeer lichen

denotes species for which fact sheets are available in Appendix F

Table 4-18 Understory species for target ecosite d

Name	Common name
Tree Stratum	
Abies balsamea	balsam fir
Betula papyrifera	white birch
Picea glauca	white spruce
Picea mariana	black spruce
Populus balsamifera	balsam poplar
Populus tremuloides	aspen
Shrub Stratum	
Alnus viridis	green alder
Amelanchier alnifolia	saskatoon
Corylus cornuta	beaked hazelnut
Ledum groenlandicum	common Labrador tea
Linnaea borealis	twinflower
Ribes americanum	wild black currant
Ribes lacustre	bristly black currant
Ribes oxyacanthoides	northern gooseberry
Ribes triste	wild red currant
Rosa acicularis	prickly rose
Rubus idaeus	wild red raspberry
Rubus pubescens	dewberry
Salix athabascensis	Athabasca willow
Salix bebbiana	beaked willow
Salix discolor	pussy willow
Salix drummondiana	Drummond's willow
Salix glauca	smooth willow
Salix myrtillifolia	myrtle-leaved willow
Salix scouleriana	Scouler's willow
Shepherdia canadensis	Canada buffaloberry
Symphoricarpos albus	snowberry
Viburnum edule	low-bush cranberry
Forb Stratum	
Aralia nudicaulis	wild sarsaparilla
Aster conspicuus	showy aster
Cornus canadensis	bunchberry
Epilobium angustifolium	common fireweed
Fragaria virginiana	wild strawberry
Galium triflorum	sweet-scented bedstraw
Lathyrus ochroleucus	cream-colored vetchling
Maianthemum canadense	wild lily-of-the-valley
Mertensia paniculata	tall lungwort
Mitella nuda	bishop's-cap
Petasites frigidus var palmatus	palmate-leaved coltsfoot
Pyrola asarifolia	common pink wintergreen
Grass Stratum	
Calamagrostis canadensis	bluejoint
Leymus innovatus	hairy wild rye
Moss Stratum	
Hylocomium splendens	stair-step moss
Ptilium crista-castrensis	knight's plume moss

denotes species for which fact sheets are available in Appendix F

Table 4-19 Understory species for target ecosite e

Name	Common name
Tree Stratum	
Abies balsamea	balsam fir
Betula papyrifera	white birch
Picea glauca	white spruce
Populus balsamifera	balsam poplar
Populus tremuloides	aspen
Shrub Stratum	
Alnus viridis	green alder
Alnus incana spp. *tenuifolia*	river alder
Amelanchier alnifolia	saskatoon
Cornus stolonifera	red-osier dogwood
Linnaea borealis	twinflower
Lonicera involucrata	bracted honeysuckle
Ribes americanum	wild black currant
Ribes glandulosum	skunk currant
Ribes hudsonianum	northern blackcurrant
Ribes lacustre	bristly black currant
Ribes oxyacanthoides	northern gooseberry
Rosa acicularis	prickly rose
Rubus idaeus	wild red raspberry
Rubus pubescens	dewberry
Salix athabascensis	Athabasca willow
Salix bebbiana	beaked willow
Salix discolor	pussy willow
Salix drummondiana	Drummond's willow
Salix glauca	smooth willow
Salix myrtillifolia	myrtle-leaved willow
Salix scouleriana	Scouler's willow
Salix spp.	willow
Viburnum edule	low-bush cranberry
Forb Stratum	
Aralia nudicaulis	wild sarsaparilla
Cornus canadensis	bunchberry
Epilobium angustifolium	common fireweed
Equisetum arvense	common horsetail
Equisetum sylvaticum	woodland horsetail
Mertensia paniculata	tall lungwort
Mitella nuda	bishop's-cap
Grass Stratum	
Calamagrostis canadensis	bluejoint

denotes species for which fact sheets are available in Appendix F

Table 4-20 Understory species for target ecosite f

Name	Common name
Tree Stratum	
Abies balsamea	balsam fir
Betula papyrifera	white birch
Picea glauca	white spruce
Populus balsamifera	balsam poplar
Populus tremuloides	aspen
Shrub Stratum	
Alnus viridis	green alder
Cornus stolonifera	red-osier dogwood
Linnaea borealis	twinflower
Ribes americanum	wild black currant
Ribes glandulosum	skunk currant
Ribes hudsonianum	northern blackcurrant
Ribes lacustre	bristly black currant
Ribes oxyacanthoides	northern gooseberry
Rosa acicularis	prickly rose
Rubus idaeus	wild red raspberry
Rubus pubescens	dewberry
Salix athabascensis	Athabasca willow
Salix bebbiana	beaked willow
Salix discolor	pussy willow
Salix drummondiana	Drummond's willow
Salix glauca	smooth willow
Salix myrtillifolia	myrtle-leaved willow
Salix scouleriana	Scouler's willow
Salix spp.	willow
Viburnum edule	low-bush cranberry
Forb Stratum	
Aralia nudicaulis	wild sarsaparilla
Cornus canadensis	bunchberry
Equisetum arvense	common horsetail
Equisetum pratense	meadow horsetail
Mertensia paniculata	tall lungwort
Mitella nuda	bishop's-cap
Grass Stratum	
Calamagrostis canadensis	bluejoint
Moss Stratum	
Hylocomium splendens	stair-step moss
Pleurozium schreberi	big red stem/Schreber
Ptilium crista-castrensis	knight's plume moss

denotes species for which fact sheets are available in Appendix F

Table 4-21 Understory species for target ecosite g

Name	Common name
Tree Stratum	
Picea mariana	black spruce
Pinus banksiana	jack pine
Shrub Stratum	
Ledum groenlandicum	common Labrador tea
Linnaea borealis	twinflower
Rosa acicularis	prickly rose
Vaccinium myrtilloides	common blueberry
Vaccinium vitis-idaea	bog cranberry
Forb Stratum	
Cornus canadensis	bunchberry
Equisetum sylvaticum	woodland horsetail
Moss Stratum	
Hylocomium splendens	stair-step moss
Pleurozium schreberi	big red stem/Schreber
Ptilium crista-castrensis	knight's plume moss
Sphagnum spp.	peat moss
Lichen Stratum	
Cladina mitis	green/yellow reindeer lichen
Cladina rangiferina	grey reindeer lichen
Cladina stellaris	northern/star reindeer lichen
Cladonia gracilis	slender cup lichen

denotes species for which fact sheets are available in Appendix F

Table 4-22 Understory species for target ecosite h

Name	Common name
Tree Stratum	
Picea glauca	white spruce
Picea mariana	black spruce
Shrub Stratum	
Ledum groenlandicum	common Labrador tea
Linnaea borealis	twinflower
Rosa acicularis	prickly rose
Salix spp.	willow
Vaccinium vitis-idaea	bog cranberry
Forb Stratum	
Cornus canadensis	bunchberry
Equisetum arvense	common horsetail
Equisetum pratense	meadow horsetail
Equisetum sylvaticum	woodland horsetail
Grass Stratum	
Calamagrostis canadensis	bluejoint
Moss Stratum	
Hylocomium splendens	stair-step moss
Pleurozium schreberi	big red stem/Schreber
Ptilium crista-castrensis	knight's plume moss

denotes species for which fact sheets are available in Appendix F

4.5.2. Establishment Densities

The previous Revegetation Manual (1998) recommended a shrub planting density of 500 to 700 stems per hectare, based on conventional reclamation practice at that time. Empirical data from stands recovering from other (less severe) disturbances (logging, fire) indicate much higher early-seral understory densities (typical understory densities reported in a summary review of applicable literature range from 15,000-40,000 stems per hectare - see Appendix G). However, currently there are no empirical data available that relate reclaimed understory planting densities to subsequent population growth and resilience. Thus, the 1998 recommendation is adopted in this version of the manual as a minimum planting density for understory establishment based primarily on nursery seedling production and out-planting. Operators are encouraged to employ reclamation methods (e.g., application of LFH amendments) that will increase the density and diversity of the understory to levels more typical of juvenile stands in the region.

Note that in addition to the above 500-700 stems-per-hectare guideline, understory planting-density prescriptions should be developed with reference to the minimum target numbers of characteristic species by site type presented in Section 5. Values for threshold and mean numbers of characteristic species in Table 5-3 correspond to per-hectare densities in 100s (as these values are based on 100 m^2 plots). For example, the Moist-Rich site type has a threshold characteristic species value of 7. This value is not achievable with a planting density of 500 stems per hectare (unless augmented by species ingress), and the only way to achieve it with a planting density of 700 stems per hectare would be to have stems evenly distributed among 7 characteristic species and have no mortality, or to have species ingress between planting and assessment. It is therefore recommended that operators consider increasing understory planting densities in light of Section 5 targets/minima, where container seedling outplanting is the only method of understory species establishment (where significant ingress is expected, planting densities could be correspondingly reduced - see LFH section below). This recommendation is particularly emphasized for site types with higher threshold values, such as the Moist Rich (d/e) site type.

4.5.3. Use of Upland Surface Soils/LFH Amendments Materials

Historically, establishment of woody plant species on reclaimed landscapes in the Athabasca Oil Sands Region (AOSR) relied on out-planting of desired species with an expectation that additional species would eventually become established through ingress. Research evidence collected over three years on micro- and meso-scale plots for ecosites a, b and d suggests that utilizing the LFH layer and upper 10 to 30 cm of upland forest soils as a source of propagules (seeds and vegetative plant parts) enhances the abundance and diversity of woody plants on reclaimed landscapes, such that fewer trees and shrubs may be required for out-planting (MacKenzie 2009; Mackenzie and Naeth 2007; Mackenzie 2006; details in Appendix G).

In this manual, the term "LFH" is used generically to describe forest floor materials accumulated on the mineral soil surface under upland forests. The term "upland surface soils" is used to describe shallow-salvaged materials consisting of LFH layers and the upper 10-30 cm of underlying mineral soils (LFH layers plus A horizon). The term "LFH amendment" is used to describe salvaged upland surface soil materials used as soil capping/cover during reclamation.

4.5.4. Evidence of Effectiveness of LFH Amendments

There has been substantial research to assess the effects of the addition of LFH amendments on native plant establishment and diversity on various reclaimed landscapes in the AOSR. The majority of studies have shown successful results in increasing the abundance and diversity of upland plant communities, with woody stem densities on LFH amendment-treated plots ranging from approximately 4,000-100,000 stems per hectare 1-3 growing seasons after placement, compared to substantially lower values for non-treated plots. For most herbaceous plant species, those that are present at the upland donor site will establish successfully at the receiving site, provided similar moisture and nutrient regimes exist. For a more complete discussion of these research results, see Appendix G.

4.5.5. Salvage, Stockpiling and Application Considerations

A summary of research to date (see Appendix G for a more detailed summary) on use of LFH amendments indicates the following:

- **Salvage** - Depth of upland surface soil salvage (10-cm versus 25-cm salvage depths) has relatively little effect on resultant vegetation establishment, in comparison to stockpiling and application considerations.
- **Stockpiling** - Storage of LFH amendment in small stockpiles (typical windrows) has been shown to maintain propagule viability more effectively than storage in large (operational-sized) stockpiles. However, results to date indicate that the majority of propagules do not retain their viability when stored for durations greater than 12 months under any configuration.
- **Application** - Greatest regeneration results have been obtained using LFH amendments applied directly after salvage (not stockpiled), and placed in thicker layers (approximately 20 cm) on mineral (as opposed to peat/mineral) substrates. However, thinner placements (approximately 10 cm) have also demonstrated substantial regeneration after three growing seasons. Preliminary results indicate higher establishment densities in larger patches of LFH placement.

4.5.6. Guidance on Use of LFH Amendments

Research and operational trials conducted to date in oil sands reclamation indicate that effective salvage and application of LFH amendments has the potential to be the most successful technique for re-establishment of understory species density and diversity (see Appendix G for more detailed information). Therefore, this manual provides guidance on reductions in planting densities on sites where LFH amendments are applied. As noted above, successful vegetation re-establishment will be maximized when the soil nutrient and moisture regimes of the donor and replacement sites are similar. For this reason, it is recommended that LFH amendments be used within the same site type from which they were salvaged. However, it is likely more beneficial to use LFH treatments in a mismatched scenario than not to use them at all, or to stockpile them for longer periods. Due to limited supply of LFH amendments, operators may wish to apply these materials primarily in cases where a robust and diverse understory, as opposed to a fully stocked overstory, is desired (e.g., where the target end land-use is wildlife habitat or traditional use, rather than commercial forestry). Because LFH amendments are considered a high value reclamation material resource, the placement area should be determined strategically when applying LFH amendments.

Figure 4-2 provides values for expected contributions to overstory and understory densities from LFH amendments used under different conditions. This figure summarizes information to date on results from LFH amendment trials, and is based on salvage, storage and placement techniques that are aimed at maintaining propagule viability. Operators can use values in Figure 4-2 to reduce densities correspondingly from other establishment techniques (at this time primarily planting of container seedling stock) to meet overall target densities. This figure should be used in conjunction with Table 4-23, which presents information on species expected to regenerate from application of LFH amendments. At this time it is recommended that, where commercial forest is the target end land-use, overstory planting densities should not be reduced for LFH-amendment application, to ensure achievement of fully stocked stands.

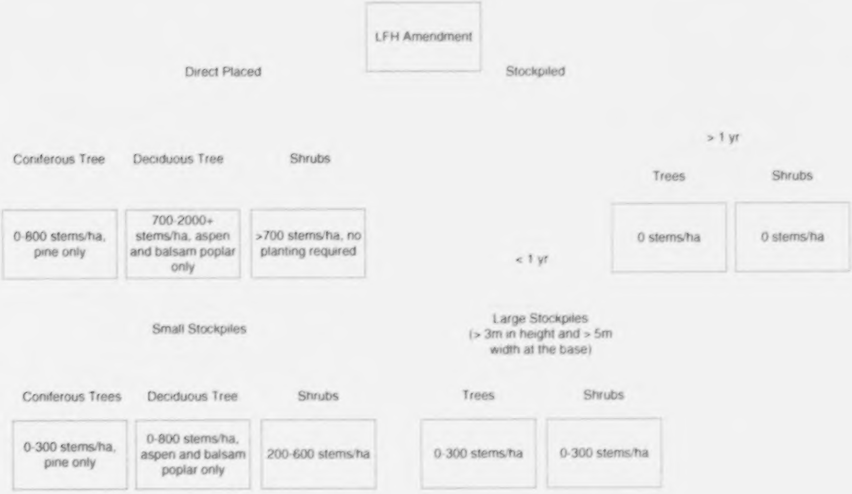

LFH Amendment
Direct Placed
Stockpiled
> 1 yr
Coniferous Tree
Deciduous Tree
Shrubs
Trees
Shrubs
0-800 stems/ha, pine only
700-2000+ stems/ha, aspen and balsam poplar only
>700 stems/ha, no planting required
0 stems/ha
0 stems/ha
< 1 yr
Small Stockpiles
Large Stockpiles (> 3m in height and > 5m width at the base)
Coniferous Trees
Deciduous Tree
Shrubs
Trees
Shrubs
0-300 stems/ha, pine only
0-800 stems/ha, aspen and balsam poplar only
200-600 stems/ha
0-300 stems/ha
0-300 stems/ha

Figure 4-2 **Expected contributions to overstory and understory densities from application of LFH amendments**

Table 4-23 Species expected to regenerate from application of fresh LFH amendments

Species		Source Ecosite		
Scientific Name	**Common Name**	**a**	**b**	**d**
Forb Stratum				
Pinus banksiana	jack pine	•••	•••	
Populus balsamifera	balsam poplar			••
Populus tremuloides	aspen	••	••••	•••
Shrub Stratum				
Alnus viridis	green alder	•••	•••	
Amelanchier Alnifolia	saskatoon	••••	••••	••••
Arctostaphylos uva-ursi	common bearberry	••••	••••	
Prunus pensylvanica	pin cherry	••••	••••	••
Ribes spp.	currant			
Rosa acicularis	prickly rose	••••	••••	
Rubus idaeus	wild red raspberry		••	••••
Salix spp.	willow			••
Symphoricarpos occidentalis	buckbrush		••	••••
Vaccinium myrtilloides	common blueberry	••••	••••	••

Sparse - 10 to 100 stems ha^{-1}	••
Moderate - 100 to 500 stems ha^{-1}	•••
Abundant - >900 stems ha^{-1}	••••

The following assumptions guide the use of Figure 4-2 - if these assumptions are not met, the recommended density reductions from expected LFH amendment contributions are not valid:

- Sites must receive a minimum of 10 cm of LFH amendment salvaged from surface soils to a depth of no greater than 30 cm.
- LFH amendment contributions to conifer densities are only applicable for jack pine, and for upland surface soils salvaged from a and b ecosites containing jack pine cones.

Additional guidance and interpretation on the use of LFH amendments is provided below:

- As with more conventional reforestation practices, monitoring tree and shrub establishment within the first two to three years following application of an LFH amendment will be required to ensure that regeneration is providing target densities; otherwise, additional planting may be required.
- Reclaimed landscapes that receive greater than 10 cm of LFH amendment and surface soils, including the LFH layer, that have been salvaged at shallower depths will provide greater densities of woody plants and the canopy cover will also be greater.
- Benefits from the propagule bank are greatest when LFH amendments are directly placed versus stockpiled.
- It is recommended that the lower end of the range of expected contributions be used on drier (southern) aspects.

- White spruce is not a seed banking species and its contribution to the propagule bank in the LFH amendment is limited to masting years; therefore, it is not included as an expected regenerating species.
- Both jack pine and black spruce maintain a seed bank, aerially and near the surface soil; however, data has only been collected for jack pine. Operators are encouraged to salvage cones from jack pine and black spruce stands as a seed source for reclaimed landscapes. Longer term data and additional research will be required to make a more accurate estimate of planting densities for these trees.

4.5.7. Species Expected from LFH Amendments

The species that establish through natural recovery will be dependent on the abundance and composition of existing and seed bank species on the donor site prior to soil salvaging. Table 4-23 summarizes the relative densities for regularly observed tree and shrub species that have established at research sites within the AOSR. Note that this table provides information for ecosites a, b and d only, as information is not available for the other upland ecosites. Operators salvaging upland surface soils from and replacing LFH amendments on ecosites c and e-h can utilize expected density contributions presented in Figure 4-2, but should expect that regenerating species will be different from those listed in Table 4-23.

4.6. Future Steps for Revegetation Planning and Management

Continuous evaluation of the revegetation planning guidance provided in Section 4.0 will lead to refinement in best management practices and development of adaptive management strategies. Improvements in revegetation planning may be informed by some key elements such as the following:

- Micro-site preparation and adjustments (e.g., coarse woody debris);
- Site-specific limitations that drive operational adjustments to microsite creation and/or selection and subsequent species selection;
- Multiple entry into reclamation polygons (e.g., ploughing of grass cover and placement of LFH under an open overstory to promote establishment of understory diversity);
- Development of a risk matrix tool to manage uncertainties around climate, insects and plant disease and to assess reclamation prescription options;
- Greater range of establishment densities for overstory and understory species;
- Operational data regarding mortality rates;
- Use of early seral species as nurse crops to ameliorate soil and meso- or micro-climate constraints (e.g. soil moisture);
- Definition of typical or generic re-establishment trajectories of plant community development;
- Response to stochastic events (e.g., drought years, insect outbreaks, late spring – early summer frost events);
- Refinement and articulation of a process for operators to design revegetation plans in collaboration with regional communities to best support Traditional Land Use and ensure that design and execution meet the current and future needs of regional communities; and
- Slope recommendations for tailings sand slopes.

5. Indicators of Revegetation Success and Monitoring Revegetation Performance

This section provides information on indicators that are required to be used by this manual, and on methods to assess these indicators.

5.1. Terminology

Within the context of reclamation, a **Criterion** represents a category of conditions or processes by which the success of a given set of reclamation practices is assessed. In a broad sense, criteria represent the goals and objectives of a reclamation project (CCFM 1995). **Indicators** constitute the elements of a criterion that will be used to assess the state of a reclaimed site and its progress over time, and to inform future decision making (Hickey and Innes 2005). Finally, **Measures** are those aspects of an indicator that can actually be quantified.

5.2. Indicator Selection

This manual makes a distinction between "hard" and "soft" indicators, and an intermediate category (applicable at the "measure", as opposed to "indicator" level), as follows:

Hard Indicators – indicators required by this manual that were selected using the following principles:

1. The indicator must be based on a well-developed knowledge, such that it contributes to a sound overall assessment of revegetation success.
2. The indicator must have applicable and defensible thresholds such that success or failure with respect to relevant indicator measures can be assessed adequately.
3. The indicator must be suitable for use on all assessment units (e.g., reclamation polygons, defined terrain units). A more thorough discussion of indicators and monitoring, and use of a wider range of indicators, is provided in Proposed Criteria and Indicators of Ecosystem Function for Reclaimed Oil Sands Sites (CEMA 2006b).
4. Based on the above three principles, the indicator must be applicable to assessments for Reclamation Certification.

The enumeration of the principles above is not intended to imply that the hard indicators required by this manual constitute a comprehensive assessment of revegetation or reclamation success, or that they are devoid of limitations. These indicators were selected for required use at this time because of relatively well-developed knowledge around their use, and/or because of more significant limitations on use of other indicators. It is fully acknowledged that these indicators/measures and their attendant thresholds may be altered, or even completely replaced, in future editions of this manual. Note that hard indicators may only be applicable to certain target end land-uses.

Intermediate Category – applies to measures required by this manual on all assessment units (reclamation polygons, defined terrain units), but which will be evaluated based on trends rather than thresholds, with no defined limits for success/failure. Further detail is provided below for relevant measures and in Appendix B.

Soft Indicators – are those identified through development of this manual, which have potential for application to revegetation or reclamation monitoring, but did not meet the above principles for hard indicator selection, primarily for the following reasons:

1. The indicator is covered by other reclamation manuals (e.g., soil nitrogen and the LCCS). Although its application may require some improvement, the current model indicates that work should occur within the framework of development of the other manuals.
2. The indicator is insufficiently developed for immediate threshold- or trend-based application, either due to insufficient protocols around survey/sampling/interpretation of its measures, or to insufficient knowledge for definition of suitable thresholds/trends.

It is the explicit intention that these soft indicators should be evaluated for future application in the Revegetation Manual indicators and monitoring program. This evaluation would occur either through targeted projects or through inclusion of the indicator in the TSG permanent plot network, or both. The outcome of this evaluation process is that the assessed indicators would be:

1. Adopted as required indicators for polygon-based certification monitoring, with appropriate thresholds developed for their assessment;
2. Maintained as informational (non-certification) indicators monitored for trends at the plot network level; or
3. Discarded.

It is because of this explicit intention that further discussion of soft indicators is included in Appendix B.

The required indicators selected for inclusion in this version of the Revegetation Manual are presented in Table 5-1, along with their corresponding criteria and a summary of the rationale for their selection. These indicators are discussed in the following sections. The critera described in the following table are based on one of the fundamentals of reclamation - restoration of ecological function. Without restoration of ecological function within the soil and plant community, limitations related to successful reclamation are inherent.

Table 5-1 Criteria and their associated indicators that can be used to develop a monitoring program

Criterion	Indicator	Rationale
The structure and composition of vegetation will be restored to target levels	Plant Community Composition	Primary measure of success of revegetation programs in returning communities characteristic of the locally common boreal forest
Critical ecosystem processes will be restored to target levels	Ecosystem Net Primary Productivity	Known thresholds for acceptance as commercial forest
The physical, chemical and biological properties of the soil will be restored to target levels	Soil Salinity	Known thresholds for establishment of forest overstory species and for establishment of productive forest

5.3. Plant Community Composition

As noted in Table 5-2, one of the primary goals of revegetation programs is re-establishment of vegetation communities characteristic of the locally common boreal forest. This indicator and the designated measures are intended to assess the success of reclamation actions in reaching this goal. In this manual, the term "plant community composition" refers to both presence and abundance of species.

5.3.1. Data Collection Protocol

All information necessary for assessment of this indicator can be collected through a variety of standard vegetation plot methods that include both:

1. Identification of all species (vascular and non-vascular) within the plot; and
2. An estimate, visual or otherwise, of specific percent cover or other abundance measure.

It is intended that this indicator be assessed over time, with assessments prior to and at the time of application for certification. "Intermediate" measures require these repeated assessment to provide trends for evaluation; hard measures will ultimately be judged versus their designated thresholds, but trend information supporting these individual values will be important in data interpretation and in refining understanding of reclamation trajectories.

Currently, approved methods would be based on those used in the TSG Permanent Plot Network (see Vegetation Protocol Manual), which is based on vegetation assessment within a 10 x 40 m "modified Whitaker plot"; however, this assessment method is currently undergoing evaluation and potential modification/replacement. Note that determination of threshold and mean characteristic species values (e.g., Table 5.3) is based on a 100 m^2 assessment area – thus this metric must be based on assessment in this plot size.

Collection of species presence and abundance information allows calculation of a number of plant community metrics such as species richness, diversity, evenness, per cent similarity with a defined benchmark. These metrics are used in this manual as intermediate plant community composition measures (Appendix B).

5.3.2. Selected Hard Measures and Thresholds

There are two selected measures and corresponding thresholds for this indicator, as summarized in Table 5-2, below:

Table 5-2 Hard measures and thresholds for the plant community composition indicator

Measure	Threshold
Number of Characteristic Species	As per Section 5.3.3
Number of Restricted Weeds	0

5.3.3. Characteristic Species

At the time of assessment for Reclamation Certification, reclaimed sites should have enough characteristic species to be identifiable as a site type or sub-category (ecosite, ecosite phase, plant community type) – for a definition of characteristic species, see Section 3. The threshold used for the characteristic species indicator is the lower 95th% confidence interval of an estimate of central tendency and normal distribution derived from regional plot data per site type (Table 5-3), where possible from juvenile stands (see GDC and FORRx 2008 and GDC 2009). Sites that do not meet this threshold have less than a 5% chance of being comparable to a "locally common boreal forest" population in terms of vegetation community composition.

Threshold numbers of species by site type are presented in Table 5-3, along with mean values for this parameter and values from older stands (to provide an indication of progression in this parameter as stands mature). The thresholds and means were determined using data described in the Vegetation Data Synthesis (see GDC and FORRx 2008, Table 2.1). Additional plot data used to supplement the dataset for ecosites f, g and h was obtained with permission from three proponents from baseline vegetation surveys conducted to support environmental impact assessments (see GDC 2009).

Ecosite, age classes and canopy composition types were used to group the plot data. Based on previous analyses (see GDC and FORRx 2008 and GDC 2009), the plots were grouped into two age classes, under 20 years old and 20 years or older. To develop the thresholds and means, ecosites were grouped into site types for analysis (e.g., Dry, Moist Rich, and Wet Rich site types). Note that in some cases, thresholds are not based on data from stands in the 0-20-year age class, as data from this class were insufficient (n=<10) for development of a reliable threshold number. In these cases, thresholds were set based on data from the 20+ year age class. A review of values presented in Table 5-3 will indicate that these values (and their derivation method) are intended to be conservative (low) with respect to realistic achievement of thresholds.

Table 5-3 Threshold species numbers by site type

Site Type	Sub-Class	Threshold[1]	Mean	Age Class 20+ Min	Age Class 20+ Mean
Dry (a/b)	Pure Pj[2]	2	7	2	7
	Aw, Sw, Mix	4	10	6	13
Moist Poor (c)		3	9	3	9
Moist Rich (d/e)		7	15	10	20
Wet Poor (g)		2	7	2	7
Wet Rich (f/h)		6	14	6	14

▨ Indicates threshold values are derived from 20+-year age

[1] Note: the threshold numbers are presented as interim targets until additional field research is undertaken. As a result of limited sample size for several site types, field data is required to better understand patterns of vegetation establishment on juvenile stands in the region. Specifically, additional 100 m^2 plots must be established on young regenerating stands (fire, harvest origin) to characterize the mean and variation associated with characteristic species establishment at the plot level in natural stands. In addition, historic sampling protocols on reclaimed sites preclude a comparison of existing reclamation areas to these thresholds. Characterization of species richness in reclaimed areas (including the established long-term permanent monitoring plots), using similar plot sizes is required.

[2] Note that this sub-class is intended only for application where jack pine-lichen ecosites are targeted.

Lists of characteristic species corresponding to each site type are presented in Tables 5-4 through 5-8, on the following pages. For each site type, characteristic species for the ecosites comprising the site type were compiled. Ecosite characteristic species were selected using the same criteria used to develop the Field Guide to Ecosites of Northern Alberta (Beckingham and Archibald 1996) based on prominence of 20 and/or frequency of 70%. For each ecosite, all species that met the criteria were combined regardless of ecosite phase or plant community type to come up with a single characteristic species list. There are 11 overlapping species for ecosites a and b, 28 overlapping species for ecosites d and e, and 11 overlapping for ecosites f and h.

Table 5-4 Characteristic species for dry site type

Name	Common name
Tree Stratum	
Betula papyrifera	white birch
Picea glauca	white spruce
Pinus banksiana	jack pine
Populus tremuloides	aspen
Shrub Stratum	
Alnus viridis	green alder
Amelanchier alnifolia	saskatoon
Arctostaphylos uva-ursi	common bearberry
Hudsonia tomentosa	sand heather
Ledum groenlandicum	common Labrador tea
Linnaea borealis	twinflower
Rosa acicularis	prickly rose
Salix athabascensis	Athabasca willow
Salix bebbiana	beaked willow
Salix discolor	pussy willow
Salix drummondiana	Drummond's willow
Salix glauca	smooth willow
Salix myrtillifolia	myrtle-leaved willow
Salix scouleriana	Scouler's willow
Shepherdia canadensis	Canada buffaloberry
Vaccinium myrtilloides	common blueberry
Vaccinium vitis-idaea	bog cranberry
Forb Stratum	
Aralia nudicaulis	wild sarsaparilla
Cornus canadensis	bunchberry
Epilobium angustifolium	common fireweed
Maianthemum canadense	wild lily-of-the-valley
Grass Stratum	
Calamagrostis canadensis	bluejoint
Leymus innovatus	hairy wild rye
Moss Stratum	
Hylocomium splendens	stair-step moss
Pleurozium schreberi	big red stem/Schreber
Polytrichum piliferum	awned hair-cap
Lichen Stratum	
Cladina mitis	green/yellow reindeerreindeer lichen
Cladina rangiferina	grey reindeer lichen
Cladina stellaris	northern/star reindeerreindeer lichen
Cladonia gracilis	slender cup lichen

denotes species for which fact sheets are available in Appendix F

Table 5-5 **Characteristic species for moist poor site type**

Name	Common name
Tree Stratum	
Picea mariana	black spruce
Pinus banksiana	jack pine
Shrub Stratum	
Alnus viridis	green alder
Empetrum nigrum	crowberry
Ledum groenlandicum	common Labrador tea
Linnaea borealis	twinflower
Rosa acicularis	prickly rose
Salix athabascensis	Athabasca willow
Salix bebbiana	beaked willow
Salix discolor	pussy willow
Salix drummondiana	Drummond's willow
Salix glauca	smooth willow
Salix myrtillifolia	myrtle-leaved willow
Salix scouleriana	Scouler's willow
Vaccinium myrtilloides	common blueberry
Vaccinium vitis-idaea	bog cranberry
Forb Stratum	
Cornus canadensis	bunchberry
Equisetum sylvaticum	woodland horsetail
Lycopodium annotinum	stiff club-moss
Pyrola asarifolia	common pink wintergreen
Moss Stratum	
Hylocomium splendens	stair-step moss
Pleurozium schreberi	big red stem/Schreber
Ptilium crista-castrensis	knight's plume moss
Lichen Stratum	
Cladina mitis	green/yellow reindeer lichen
Cladina rangiferina	grey reindeer lichen
Cladina stellaris	northern/star reindeer lichen

denotes species for which fact sheets are available in Appendix F

Table 5-6 Characteristic species for moist rich site type

Name	Common name
Tree Stratum	
Abies balsamea	balsam fir
Betula papyrifera	white birch
Picea glauca	white spruce
Picea mariana	black spruce
Populus balsamifera	balsam poplar
Populus tremuloides	aspen
Shrub Stratum	
Alnus viridis	green alder
Alnus incana spp. *tenuifolia*	river alder
Amelanchier alnifolia	saskatoon
Cornus stolonifera	red-osier dogwood
Corylus cornuta	beaked hazelnut
Ledum groenlandicum	common Labrador tea
Linnaea borealis	twinflower
Lonicera involucrata	bracted honeysuckle
Ribes americanum	wild black currant
Ribes glandulosum	skunk currant
Ribes hudsonianum	northern blackcurrant
Ribes lacustre	bristly black currant
Ribes oxyacanthoides	northern gooseberry
Ribes triste	wild red currant
Rosa acicularis	prickly rose
Rubus idaeus	wild red raspberry
Rubus pubescens	dewberry
Salix athabascensis	Athabasca willow
Salix bebbiana	beaked willow
Salix discolor	pussy willow
Salix drummondiana	Drummond's willow
Salix glauca	smooth willow
Salix myrtillifolia	myrtle-leaved willow
Salix scouleriana	Scouler's willow
Salix spp.	willow
Shepherdia canadensis	Canada buffaloberry
Symphoricarpos albus	snowberry
Viburnum edule	low-bush cranberry
Forb Stratum	
Aralia nudicaulis	wild sarsaparilla
Aster conspicuus	showy aster
Cornus canadensis	bunchberry
Epilobium angustifolium	common fireweed
Equisetum arvense	common horsetail
Equisetum sylvaticum	woodland horsetail
Fragaria virginiana	wild strawberry
Galium triflorum	sweet-scented bedstraw
Lathyrus ochroleucus	cream-colored vetchling
Maianthemum canadense	wild lily-of-the-valley
Mertensia paniculata	tall lungwort
Mitella nuda	bishop's-cap
Petasites frigidus var palmatus	palmate-leaved coltsfoot
Pyrola asarifolia	common pink wintergreen
Grass Stratum	
Calamagrostis canadensis	bluejoint
Leymus innovatus	hairy wild rye
Moss Stratum	
Hylocomium splendens	stair-step moss
Ptilium crista-castrensis	knight's plume moss

denotes species for which fact sheets are available in Appendix F

Table 5-7 Characteristic species for wet poor site type

Name	Common name
Tree Stratum	
Picea mariana	black spruce
Pinus banksiana	jack pine
Shrub Stratum	
Ledum groenlandicum	common Labrador tea
Linnaea borealis	twinflower
Rosa acicularis	prickly rose
Vaccinium myrtilloides	common blueberry
Vaccinium vitis-idaea	bog cranberry
Forb Stratum	
Cornus canadensis	bunchberry
Equisetum sylvaticum	woodland horsetail
Moss Stratum	
Hylocomium splendens	stair-step moss
Pleurozium schreberi	big red stem/Schreber
Ptilium crista-castrensis	knight's plume moss
Sphagnum spp.	peat moss
Lichen Stratum	
Cladina mitis	green/yellow reindeerreindeer lichen
Cladina rangiferina	grey reindeer lichen
Cladina stellaris	northern/star reindeerreindeer lichen
Cladonia gracilis	slender cup lichen

denotes species for which fact sheets are available in Appendix F

Table 5-8 Characteristic species for wet rich site type

Name	Common name
Tree Stratum	
Abies balsamea	balsam fir
Betula papyrifera	white birch
Picea glauca	white spruce
Picea mariana	black spruce
Populus balsamifera	balsam poplar
Populus tremuloides	aspen
Shrub Stratum	
Alnus viridis	green alder
Cornus stolonifera	red-osier dogwood
Ledum groenlandicum	common Labrador tea
Linnaea borealis	twinflower
Ribes americanum	wild black currant
Ribes glandulosum	skunk currant
Ribes hudsonianum	northern blackcurrant
Ribes lacustre	bristly black currant
Ribes oxyacanthoides	northern gooseberry
Rosa acicularis	prickly rose
Rubus idaeus	wild red raspberry
Rubus pubescens	dewberry
Salix athabascensis	Athabasca willow
Salix bebbiana	beaked willow
Salix discolor	pussy willow
Salix drummondiana	Drummond's willow
Salix glauca	smooth willow
Salix myrtillifolia	myrtle-leaved willow
Salix scouleriana	Scouler's willow
Salix spp.	willow
Vaccinium vitis-idaea	bog cranberry
Viburnum edule	low-bush cranberry
Forb Stratum	
Aralia nudicaulis	wild sarsaparilla
Cornus canadensis	bunchberry
Equisetum arvense	common horsetail
Equisetum pratense	meadow horsetail
Equisetum sylvaticum	woodland horsetail
Mertensia paniculata	tall lungwort
Mitella nuda	bishop's-cap
Grass Stratum	
Calamagrostis canadensis	bluejoint
Moss Stratum	
Hylocomium splendens	stair-step moss
Pleurozium schreberi	big red stem/Schreber
Ptilium crista-castrensis	knight's plume moss

denotes species for which fact sheets are available in Appendix F

5.3.4. Evaluation of Characteristic Species

For each assessed reclamation polygon, the mean number of characteristic species (based on 100 m^2 plot data, averaged across all plots in the polygon) must meet applicable thresholds (presented in Table 5-3) at the time of certification application. The process for evaluation is as follows:

1. Evaluate plot data versus site type appropriate to target ecosite. If threshold is achieved, the assessed area is defined as successfully reclaimed with respect to this indicator—proceed to step 1a. If threshold is not met, proceed to step 2.
    a. If classification to ecosite level is desired, consult Appendix J.
2. Evaluate plot data versus other site types. If threshold is achieved for another site type, reassign polygon site type designation. The assessed area is defined as successfully reclaimed with respect to this indicator - proceed to step 2a. If threshold is not met, proceed to step 3.
    a. If classification to ecosite level is desired, consult Appendix J.
3. The polygon is in a non-certifiable state, and must be remediated (e.g., in-fill planted) prior to re-assessment.

5.3.5. Restricted Weeds

Restricted weeds are non-native species that pose a serious threat because of their ability to spread rapidly and out-compete natural vegetation. Section 31(a) of the *Weed Control Act* states that "owners or occupants of land shall as often as necessary destroy all restricted weeds located on the land to prevent the spread, growth, ripening or scattering of the restricted weeds." Restricted weeds are listed in Table 5-9 and Appendix A, below.

Table 5-9 Restricted weeds

Scientific Name	Common Name	Vegetation Type
Carduus nutans	Nodding thistle	Forb
Centaurea diffusa	Diffuse knapweed	Forb
Centaurea maculosa	Spotted knapweed	Forb
Centaurea solstitialis	Yellow star-thistle	Forb
Cuscuta spp.	Dodder	Forb
Myriophyllum spicatum	Water-milfoil	Forb
Odontites serotina	Red Bartsia	Forb

5.3.6. Evaluation of Restricted Weeds

The absence of restricted weeds on reclaimed sites is a requisite for certification, thus the threshold for this measure is zero. Presence of restricted weeds in any vegetation plots on a reclamation polygon undergoing assessment for certification indicates that the polygon is non-certifiable, and that remedial action will be required prior to re-assessment.

5.3.7. Selected Intermediate Measures

Plant community composition is the only indicator of the three required indicators that includes intermediate measures - these are measures for which collection and interpretation is required on all reclaimed polygons, but for which certification thresholds do not exist at this time. Because these measures are trend-based, as opposed to threshold-based, their interpretation requires repeated data collection over time. These measures are included because they are central to the concept of demonstrating that reclaimed vegetation communities are on a trajectory towards communities more like those that existed prior to disturbance. However, these measures do not require dedicated data collection, as they can be calculated from the same information used for the threshold-based indicators (e.g., from plot data providing species presence and abundance). The intermediate plant community composition measures are summarized below in Table 5-10.

Table 5-10 Intermediate measures and thresholds for the plant community composition indicator

Measure	Assessment
Community composition indices (diversity, richness, evenness, abundance)	Trend-based measures, assessed over time until certification
Alien species (noxious and nuisance weeds)	

5.3.8. Community Composition Indices

Indices listed in Table 5-10 are provided as examples only - although this manual stipulates collection of vegetation trend data on all reclamation polygons, some discretion with regard to data analysis is left to appropriate professionals. The overarching intent is that an overall trajectory towards pre-disturbance vegetation conditions should be demonstrated, although, depending on the index, temporary and/or explicable negative trends may be acceptable. Further information of use of many of these indices is provided in Appendix B, and in TSG's Vegetation Data Synthesis report (GDC and FORRx 2008).

5.3.9. Alien Species

Species that have become established in areas outside their natural range are known as "alien species" (including Restricted Weeds, Section 5.3.2). Alien species do not necessarily pose a significant risk to natural communities; however, when alien species become invasive they can cause significant harm. In the case of reclamation, an abundance of alien plants could significantly hinder establishment of native flora. The result is that anticipated patterns of stand development may not be realized in a timely fashion, or perhaps at all. Hence, reclaimed communities may not develop the species complement characteristic of natural non-mined stands. As a highly disturbed environment, the establishment of alien plants within oil sands reclamation is a possibility. In most cases, these species will remain relatively rare and may incur local extirpation as stand development proceeds. Nevertheless, their presence should be monitored to ensure populations decline over time or remain within acceptable limits. Sub-categories of alien species, excepting restricted weeds (discussed in Section 5.3.2), are discussed below.

Noxious weeds are species that have the ability to spread rapidly. Section 31(b) of the *Weed Control Act* states that "owners or occupants of land shall as often as necessary control in accordance with this Act and regulations all noxious weeds located on the land to prevent the spread, growth, ripening or scattering of the noxious weeds." **Nuisance weeds** are common throughout the Province, and are often native species. Section 31(c) of the Act states that "owners or occupants of land shall as often as necessary prevent the spread or scattering of nuisance weeds." The lists of designated noxious and nuisance weeds in Alberta are provided in Appendix A.

Presence and cover of noxious and nuisance weeds should be tracked over time on all reclamation polygons (see Appendix B). This measure is intended to be evaluated based on trends, similar to the other community composition indices. For noxious and nuisance weeds, the intent is that an overall decrease in number and abundance of these species will be observed over time.

5.4. Ecosystem Net Primary Productivity

5.4.1. Background

Net primary production (NPP) is the total photosynthetic gain, less respiratory losses, of vegetation per unit ground area. Re-establishment of NPP involving the appropriate plant species and stand structure (and, therefore, wildlife habitat and various measures of biological diversity) is of central importance to successful reclamation. Visual NPP can be much lower than total NPP because below-ground NPP can be a significant component of total annual production. Ideally, NPP should be assessed from both components (Vogt et al. 1996). For a given period, this is equal to the change in plant mass plus any losses due to death and decomposition. Estimating below-ground NPP is costly, however, and there is some uncertainty regarding its measurement, particularly with respect to fine root dynamics (Pritchard and Strand 2008). Restricting estimates of NPP to the accumulation of above-ground biomass only is not without its practical difficulties either.

Due to the limitations noted above in measuring or estimating actual NPP, this manual adopts site index as a proxy measure of NPP. Site index is defined as the height of top-height trees (the 100 largest-diameter, dominant or co-dominant, undamaged/unsuppressed trees per ha) in a relatively pure, even-aged, well-stocked stand, at breast height age 50 years. Site index is considered a useful measure of productivity because it is relatively density independent, and because no other single measure better reflects the inherent capacity of a site for forest production (Huang 1994). It should be noted that the TSG is actively exploring more direct metrics/estimates of NPP for future use.

Use of site index as a hard indicator is restricted to reclaimed sites with a target primary end land-use of commercial forestry. Sites designated for wildlife habitat or traditional use will be evaluated based on the other hard indicators.

5.4.2. Data Collection Protocols

Data collection and analysis will be based on plots established in every reclamation polygon, as per the following rules:

1. Site index should be assessed using standard forestry mensuration methods on the same plots used for plant community composition (Section 5.3.1).
2. The minimum tree age/height for reliable site index assessment is 5 years past breast height. As the standard vegetation assessment protocol calls for plot establishment at the time of vegetation establishment and every subsequent 5 years, site index will be measured at the first interval in which site trees are at least 5 years past breast height, and at every subsequent re-measurement until certification.
3. As this assessment is based on top-height trees (the largest 100 trees per ha), sampling intensity will be 1 tree per plot. If assessment occurs in a mixedwood stand where two (or more) species qualify for site tree selection, then measurement can be conducted on 1 tree per plot per species. Otherwise, the single site tree should be selected for measurement.
4. Site trees should meet standard criteria for selection (e.g., be dominant or co-dominant, undamaged/unsuppressed).
5. Site trees will be selected as the most dominant qualifying tree in the plot. In younger stands where relative height can be judged accurately, this determination will be based on height. This procedure can be altered to a diameter-based determination when stands reach a state where relative height assessment becomes difficult.
6. For the selected site tree, total height and age at breast height will be determined as follows:
   a. Height measurements will be conducted using accurate methods (e.g., telescoping height poles/stadia rods or laser hypsometers).
   b. Age at breast height will be determined at 1.3 m. For indeterminate species or species that produce inter-nodal pseudowhorls (jack pine), age will be based on an increment core, with ring determination conducted under a dissecting microscope after sanding/staining. For saplings of determinate species other than pine, age determination can be done by counting annual whorls.

The above establishment and assessment protocols are designed to allow comparison to threshold values for this indicator, and to data from plots outside this program. It is acknowledged that specific circumstances might require deviation from these protocols; however, modifications should be accompanied by a detailed justification for deviation.

Note that, as described above, the minimum tree age/height for reliable site index assessment is 5 years past breast height – this minimum may have implications for certification assessment for reclaimed sites with a target end land-use of commercial forestry. It is intended that this indicator be assessed over time, with regular re-assessments following the first site index estimate. This re-measurement will likely occur after certification application is completed, but information on change in site index as reclaimed juvenile stands mature past certification age will be valuable both for:

1. Assessing whether growth-intercept equations developed from post-harvest or pyrogenic regeneration are applicable to regeneration on reclaimed sites; and
2. Collecting data necessary for development of reclamation-specific growth-intercept equations, if necessary.

The applicable SI functions derived for use in Alberta's regeneration standards, and young forest stands generally, can be obtained by contacting the Biometrics unit of Alberta Sustainable Resource Development.

5.4.3. Thresholds

Minimum site index values for successful achievement of a commercial forestry end land-use are presented in Table 5-11. These site index values are based on minimum/mean values for the "Fair" Timber Productivity Rating (TPR) Class, converted to be applicable to top-height, growth-intercept site index estimates on reclaimed sites.

The bottom of the TPR class 'Fair' is commonly the first overlay of restrictions to the commercially operable forestry landbase. However this class in operational terms never (or almost never) represents the final strata. Other subsidiary or associated parameters are also applied to the forest inventory to divide this TPR class into operable and non-operable. One example for a typical black spruce strata is the use of a height age restriction, where stands that are not on track to achieving a 14 m stand height within 110 years are not deemed operable. This requirement varies from time to time and place to place, but in general terms shows that the lower productivity component of the 'Fair' TPR is not considered operable.

Table 5-11 Minimum site index values

Species	Top Height Fair (m)	Top Height ½ Fair (m)
Aw	11.6	13.5
Bw	11.6	13.5
Pb	11.6	13.5
Pj	8.1	10.7
Sw	7.1	9.3
Sb	7.2	7.7

5.4.4. Evaluation of Site Index

For each assessed reclamation polygon, the mean site index for the leading species must meet or exceed the specific minimum value referenced in Table 5-11. Failure to achieve these threshold values means that either:

1. The polygon must be re-assigned to a target primary end land-use other than commercial forestry; or
2. The polygon is in a non-certifiable state, and must be remediated prior to re-assessment.

5.4.5. Regeneration Standards

Successful establishment of a commercial forestry end land-use also requires that regeneration standards (e.g., stocking levels, presence of acceptable overstory species) be met prior to or at the time of certification assessment, to demonstrate that a fully stocked, commercially viable stand has been established. Currently, these standards are the former provincial Regeneration Standards, including both establishment- and performance-survey criteria. These standards, and their general requirements on survey methods and achievement of an 80% stocking rate, are currently included in oil sands operators' approvals, although it is understood that:

1. The current Regeneration Standards are being replaced by operation-specific standards for forest licensees in Alberta; and
2. Development of regeneration standards specific to oil sands reclamation is desired by both regulators and operators.

Nevertheless, until these new regeneration criteria are developed, it is assumed that the current Regeneration Standards and their associated methods and criteria are applicable to reclamation of oil sands extraction sites for commercial forestry end land-uses.

5.5. Soil salinity

5.5.1. Rationale

Most reclaimed oil sands mining landscapes will have some portion of the landscape influenced by salts of varying composition (Renault et al., 1998). Although the majority of salt-affected reclaimed sites will be wetland and riparian habitats, it is possible that some reclaimed upland landscapes will be prone to salinity through the oxidation of shallow shales in saline-sodic overburden dumps or as a result of accumulated salts associated with process-affected waters in tailings landforms (Macyk et al., 2007). Excess concentrations of saline and sodic materials in soils and soil-like materials are known to negatively influence the physiological function of boreal forest species (Howat 2000) and to influence plant community composition significantly.

Diverse plant communities can thrive in upland and riparian areas where surface soil salinity exceeds 4 dS/m, but these plant communities are significantly different from equivalent non-saline boreal landscapes (Purdy et al, 2005). As a result, on any reclaimed environments where surface soils exceed or are anticipated to exceed 4 dS/m, different plant communities should be targeted for reclamation purposes than would otherwise be anticipated from standard ecosite classification (see Appendix C). In particular, lower-slope positions in saline-sodic overburden dump and tailings landforms are likely to be receiving environments for saline groundwater. In saline landscapes, these slope positions are dominated by wet-meadow vegetation as the high water table contributes to surface soil salinization, which precludes the development of treed vegetation (Close et al., 2007). Thus, some ecosites, such as f, g and h, may be difficult to establish in landforms possessing saline groundwater where the salinity approaches the surface and is at levels that exceed the tolerance of the species associated with those ecosites. Note that this discussion is particularly relevant to surface or topsoil salinity – high subsoil salinity alone is unlikely to result in shifts in plant community composition (Purdy et al., 2005; Close 2007).

Where boreal trees do occur in natural saline landscapes, surface soil salinity is typically lower than 4 dS/m, though subsurface soil salinity can be much higher (> 20 dS/m). In natural sites affected by salinity, productivity of tree species is typically low and the majority of stands would be classified as non-commercial with low site index values (Close 2007). For reclamation purposes, forested habitat can be established over reclaimed landforms anticipated to be saline; however, there are limits to acceptable surface soil salinity (e.g., 4 dS/m) for the establishment and growth of tree species, and expectations for productive stands or commercial forestry would be unrealistic.

In response to varying climatic conditions that affect precipitation, evaporation and ground and surface water flows over time, saline landscapes also exhibit considerable temporal variability (Lieffers and Shay 1983). Reclaimed landforms that have the potential to be influenced by soil salinity will thus be highly variable. Spatial variability will be in response to surface and sub-surface salinity gradients. Temporal variability will occur in response to climatic conditions, immaturity of the landforms, changes in soil pore-water salinity that will occur in response to oxidation of sub-surface saline-sodic shales, and variation in amounts and types of tailings water, depending on the landscape.

Although salinity is a soil property covered in the LCCS, it is included as a hard indicator in this manual because of its direct implications for successful establishment of vegetation communities, as above.

5.5.2. Data Collection Protocols

The soil salinity measure used in this manual is electrical conductivity (EC) of the LCCS Topsoil (0-20 cm) layer. Because of the anticipated temporal variability in salinity, it is intended that this indicator be assessed over time, with assessments prior to and at the time of application for certification.

Currently, approved methods would be based on those used in the TSG Permanent Plot Network (see the LCCS and Soils Protocol Manual); however, this assessment method is currently undergoing evaluation and potential modification/replacement.

Note that at the time of revegetation, information should exist on expected salinity levels in reclamation soil materials, either from pre-salvage soil assessment, or from post-placement LCCS evaluation. For the purpose of application of this manual, soil salinity would only be tracked on polygons where existing information or previous experience would indicate that it could present a limitation to vegetation growth. In all other cases, the only monitoring necessary would be a one-time post-placement confirmation of low salinity levels (e.g., through an LCCS audit).

5.5.3. Thresholds

Maximum EC levels for desired end land-use or end land-state targets are presented in Table 5-12. These values are based directly on research investigating salinity effects on plant communities and overstory productivity in the oil sands region (Purdy et al., 2005; Close 2007). Note that these thresholds apply to the topsoil only - at this time there are no thresholds for the Upper Subsoil and Lower Subsoil layers.

Topsoil salinity levels exceeding 4 dS/m preclude the establishment of forested ecosystems - for guidance on reclamation of such sites, refer to Appendix C.

Table 5-12 Maximum electrical conductivity levels

Target End Land-use/State	Maximum Topsoil EC (dS/m)
Commercial Forestry	2
Forested Ecosystem	4

5.5.4. Evaluation of Soil Salinity

For each assessed reclamation polygon, all topsoil salinity values must be equal to or less than the maxima presented in Table 5-12 at the time of application for certification, depending on target end land-use or desired vegetation state. Assessment is guided as follows:

- **Topsoil Salinity ≤ 2 dS/m:** any declared end land-use is successfully supported, subject to other indicators.
- **Topsoil Salinity > 2, ≤ 4 dS/m:** successful achievement of a commercial forestry end land-use is precluded. The polygon must be re-assigned to a target primary end land-use other than commercial forestry.
- **Topsoil Salinity > 4 dS/m:** successful establishment of forested ecosystems is precluded. The polygon must be treated as a special reclamation case, as per Appendix C, or remediated.

5.6. Summary

A summary of indicators and measures presented in this section, the thresholds for these measures, and implications for certification are provided in Table 5-13.

Table 5-13 **Summary of indicators**

Indicator	Category	Measures	Threshold	Assessment	Implication of Failure to Meet Threshold
Plant Community Composition	Hard	Number of Characteristic Species	Section 5.3.2	Repeated. Threshold at Certification	• Re-assignment of ecosite or site type; or • Non-certification/ remediation
	Hard	Number of Restricted Weed Species	0	Repeated. Threshold at Certification	• Non-certification/ remediation
	Intermediate	Community Composition Indices[1]	N/A	Repeated. Trend-based	N/A
	Intermediate	Alien Species[1]	N/A	Repeated. Trend-based	N/A
Ecosystem Net Primary Productivity	Hard	Site Index	Section 5.4	Repeated. Threshold at Certification	• Re-assignment of end land-use to other than commercial forest; or • Non-certification/ remediation
Soil Salinity	Hard	Electrical Conductivity (dS/m)	Section 5.5	Threshold at Certification. Repeated where confirmed elevated levels exist	• Re-assignment of end land-use to other than commercial forest; • End land state to other than forested; or • Non-certification/ remediation

[1] See Appendix B for information regarding methods for data collection of intermediate category measures.

6. Glossary of Terms

Adaptive Management	A management approach that involves the monitoring and evaluation of a reclaimed area's performance followed by any necessary actions to achieve the intended performance objectives. Adaptive management also allows information to be fed back into the planning and design process so that future reclaimed areas will meet the intended objectives.
Biodiversity	Totality of the richness of biological variation, ranging from within-species genetic variation, through subspecies and species, to communities, and the pattern and dynamics of these on the landscape.
Capability Class	A rating that indicates the capability of land for some use such as agriculture, forestry, recreation, or wildlife. In the Canadian system, it is a grouping of lands that have the same relative degree of limitation or hazard. The degree of limitation or hazard is nil in Class 1 and becomes progressively greater to Class 7.
Capping	A system designed to reduce surface water infiltration, control gas and odour emissions, improve aesthetics, and provide a stable surface cover.
Characteristic species	Those species that are either: Present in a minimum of 70% of the sample plots for a given vegetation class; or Have a prominence value of 20 or greater, where prominence value $=\sqrt{\%frequency x\%cover}$
Cover	The area of ground covered by all living (including stems and leaves) and dead (litter) plant material that is produced naturally on a site, expressed as a percentage of the total area. Bare soil is not cover. Also known as ground cover, canopy cover or aerial cover.
Crown closure	Ground area (expressed as a percentage of the total polygon area) covered by a vertical projection of tree crowns onto the ground for each identified storey.
Developmental Trajectories	The developmental pathway in terms of function or composition of an ecosystem through time.
Ecosite	Ecological unit that develops under similar environmental influences (climate, moisture, and nutrient regime). An ecosite is a group of one or more ecosite phases that occur within the same portion of the edatope (e.g., lichen ecosite). Ecosite, in this classification system, is a functional unit defined by moisture and nutrient regime. It is not tied to specific landforms or plant communities as in other systems (Lacate 1969), but is based on the combined interaction of biophysical factors that together dictate the availability of moisture and nutrients for plant growth. Thus, ecosites are different in their moisture regime and/or nutrient regime (Beckingham and Archibald, 1996).

Ecosystem	A complex of living organisms and their environment, linked by energy flows and materials cycling. An ecological community considered together with the nonliving factors of its environment as a unit.
Edaphic	(1) Of or pertaining to the soil. (2) Resulting from, or influenced by, factors inherent in the soil or other substrate rather than by climatic factors.
Edatopic grid	Soil moisture/nutrient grid that displays the potential ranges of combinations of moisture (very dry to wet or xeric to hydric moisture regimes) and nutrient (very poor to very rich) conditions (adapted from Beckingham and Archibald, 1996).
LFH	Used generically in this manual to describe forest floor materials accumulated on the mineral soil surface under upland forests.
LFH amendment	Salvaged upland surface soil materials used as soil capping/cover during reclamation.
Site type	Groups of ecosites that are conceptually defined based on the factors that control plant establishment, growth, and succession, as well as data driven similarities in ecological and floristic conditions.
Upland surface soil	Shallow-salvaged materials consisting of LFH layers and the upper 10-30 cm of underlying mineral soils (LFH layers plus A horizon).

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Appendix A—Acts and Regulations

The following information has been pulled from the *Environmental Protection and Enhancement Act* (EPEA), the associated Conservation and Reclamation Regulation and the EPEA approvals. This information outlines the requirements for operators to conserve and reclaim and sets the foundation for the value of the Revegetation Manual as a Guideline.

Under the EPEA, each operator has a duty to reclaim.

Environmental Protection and Enhancement Act

137(1) An operator must:

(a) Conserve **specified land**,

(b) Reclaim **specified land**,

(c) Unless exempted by the regulation, obtain a reclamation certificate in respect of the conservation and reclamation.

137(2) Where this Act requires that **specified land** must be conserved and reclaimed, the conservation and reclamation must be carried out in accordance with:

(a) the terms and conditions in any applicable approval or code of practice,

(b) the terms and conditions of any environmental protection order regarding conservation and reclamation that is issued under this Part,

(c) the directions of an inspector or the Director, and

(d) this Act.

Conservation and Reclamation Regulation

2 The objective of conservation and reclamation of **specified land** is to return the **specified land** to an equivalent capability.

3(1) The Director may establish standards, criteria and guidelines for conservation or reclamation of **specified land** and may develop and release information documents respecting those standards, criteria and guidelines.

3(2) An operator must:

(a) conserve **specified land**, and

(b) reclaim **specified land**

in accordance with the applicable standards, criteria and guidelines that are established by the Director.

Definitions:

Definition (t):

Specified land means land that is being or has been used or held for or in connection with:

(i) the construction, operation or reclamation of a well, an industrial pipeline or battery,
(ii) the construction, operation or reclamation of an **oil production site**,
(iii) the construction, operation or reclamation of a municipal pipeline,
(iv) the construction, operation or reclamation of a telecommunication system or transmission line,
(v) the construction, operation or reclamation of a **mine, pit**, borrow excavation, quarry or peat operation,
(vi) the construction or reclamation of a roadway,
(vii) the conduct or reclamation of an exploration operation,
(viii) the reclamation of a railway,
(ix) the construction, operation or reclamation of a **plant**,

but does not include that portion of a pit on which a waste management facility is operating or has been operated in accordance with a valid approval or registration under the Act and the regulations.

Definition (e):

Equivalent land capability means that the ability of the land to support various land uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land, but that the individual land uses will not necessarily be identical.

Definition (k):

Land capability means the ability of land to support a given land use, based on an evaluation of the physical, chemical and biological characteristics of the land, including topography, drainage, hydrology, soils and vegetation.

Definition (l):

Conservation means, except in sections 22 to 24, the planning, management and implementation of an activity with the objective of protecting the essential physical, chemical and biological characteristics of the environment against degradation.

Definition (ddd):

Reclamation means any or all of the following:

(i) the removal of equipment or buildings or other structures or appurtenances;
(ii) the decontamination of buildings or other structures or other appurtenances, or land or water;
(iii) the stabilization, contouring, maintenance, conditioning or reconstruction of the surface of land;
(iv) any other procedure, operation or requirements specified in the regulations.

EPEA Approvals

Each facility must have an EPEA approval to operate. EPEA approvals are subject to review and change over time. EPEA approvals are updated to reflect new information available through research, monitoring, and operational practices, thereby incorporating the principle of adaptive management. EPEA approvals are typically renewed on a 10-year cycle; however applications to amend the EPEA approval for any given facility may occur at any point within that 10 year period.

The EPEA approvals provide definitions specific to operational conservation and reclamation. As well, they list specific conditions related to soil salvage and placement, revegetation, forestry, fish and wildlife, biodiversity, wetlands, end pit lakes, tailings, etc. There are also conditions related to comprehensive reclamation and closure planning as well as annual reporting.

This Revegetation Manual is referenced in the EPEA approvals as a Guideline that must be followed in the development of any Revegetation Plan for an oil sands mine.

Weed Control Act

Duties re weeds

31 An occupant of land, or if the land is unoccupied, the owner of the land, shall as often as is necessary

(a) destroy all restricted weeds located on the land to prevent the spread, growth, ripening or scattering of the restricted weeds,
(b) control in accordance with this Act and the regulations all noxious weeds located on the land to prevent the spread, growth, ripening or scattering of the noxious weeds, and
(c) prevent the spread or scattering of nuisance weeds.

RSA 1980 cW 6 s31;1990 c3 s3

Weed Regulation AR 171/2001 s5;121/2006

As per Schedule 1 of the Weed Regulation, the following tables list the designated restricted, noxious and nuisance plant species in Alberta.

Table A.1 Restricted plant species

Restricted		
Scientific Name	**Common Name**	**Vegetation Type**
Carduus nutans	Nodding thistle	Forb
Centaurea diffusa	Diffuse knapweed	Forb
Centaurea maculosa	Spotted knapweed	Forb
Centaurea solstitialis	Yellow star-thistle	Forb
Cuscuta spp.	Dodder	Forb
Myriophyllum spicatum	Water-milfoil	Forb
Odontites serotina	Red bartsia	Forb

Table A.2 Noxious plant species

Noxious		
Scientific Name	**Common Name**	**Vegetation Type**
Apocynum androsaemifolium	Spreading dogbane	Forb
Cardaria spp.	Hoary cress	Forb
Centaurea repens	Russian knapweed	Forb
Chrysanthemum leucanthemum	Oxeye daisy	Forb
Cirsium arvense	Canada thistle	Forb
Convolvulus arvensis	Field bindweed	Forb
Cynoglossum officinale	Hound's-tongue	Forb
Echium vulgare	Blueweed	Forb
Erodium cicutarium	Stork's bill	Forb
Euphorbia cyparissias	Cypress spurge	Forb
Euphorbia esula	Leafy spurge	Forb
Galium aparine	Cleaver spp.	Forb
Galium spurium	Cleaver spp.	Forb
Knautia arvensis	Field scabious	Forb
Linaria vulgaris	Toadflax	Forb
Lolium persicum	Persian darnel	Forb
Lythrum salicaria	Purple loosestrife	Forb
Matricaria perforata	Scentless chamomile	Forb
Ranunculus acris	Tall buttercup	Forb
Scleranthus annuus	Knawel	Forb
Silene alba	White cockle	Forb
Silene cucubalus	Bladder campion	Forb
Sonchus arvensis	Perennial sow thistle	Forb
Tanacetum vulgare	Common tansy	Forb

Table A.3 Nuisance plant species

Nuisance		
Scientific Name	**Common Name**	**Vegetation Type**
Agropyron repens	Quack grass	Grass
Amaranthus retroflexus	Redroot pigweed	Forb
Avena fatua	Wild oats	Grass
Bromus tectorum	Downy brome	Grass
Campanula rapunculoides	Creeping bellflower	Forb
Capsella bursa-pastoris	Shepherd's purse	Forb
Cerastium arvense	Field chickweed	Forb
Cerastium vulgatum	Mouse-eared chickweed	Forb
Convolvulus sepium	Hedge bindweed	Forb
Crepis tectorum	Narrow-leaved hawk's-beard	Forb
Descurainia pinnata	Green tansy mustard	Forb
Descurainia sophia	Flixweed	Forb
Erucastrum gallicum	Dog mustard	Forb
Erysimum cheiranthoides	Wormseed mustard	Forb
Fagopyrum tataricum	Tartary buckwheat	Forb
Galeopsis tetrahit	Hemp nettle	Forb
Lamium amplexicaule	Henbit	Forb
Lappula echinata	Bluebur	Forb
Linaria dalmatica	Dalmatian toadflax	Forb
Malva rotundifolia	Round-leaved mallow	Forb
Neslia paniculata	Ball mustard	Forb
Polygonum convolvulus	Wild buckwheat	Forb
Polygonum persicaria	Lady's-thumb	Forb
Potentilla norvegica	Rough cinquefoil	Forb
Raphanus raphanistrum	Wild radish	Forb
Salsola pestifer	Russian thistle	Forb
Saponaria vaccaria	Cow cockle	Forb
Setaria viridis	Green foxtail	Grass
Silene cserei	Biennial campion	Forb
Silene noctiflora	Night-flowering catchfly	Forb
Sinapsis arvensis	Wild mustard	Forb
Sonchus oleraceus	Annual sow thistle	Forb
Spergula arvensis	Corn spurry	Forb
Stellaria media	Common chickweed	Forb
Taraxacum officinale	Dandelion	Forb
Thlaspi arvense	Stinkweed	Forb

Appendix B—Key Concepts in Monitoring

Introduction

Monitoring the success of the revegetation program is a key component in demonstrating that community development on reclaimed sites is, or is likely to, fulfill long-term objectives. When properly implemented, a monitoring program can also provide valuable information regarding successful activities and highlight issues that need to be addressed.

There are four basic types of monitoring, each of which is designed to address a specific question (Todd et al. 2007):

1. Compliance monitoring – do the activities meet legal obligations?
2. Implementation monitoring – were activities consistent with what was planned?
3. Effectiveness monitoring – are desired outcomes being met?
4. Validation monitoring – are the original assumptions correct regarding the efficacy of the revegetation prescriptions in meeting goals and objectives?

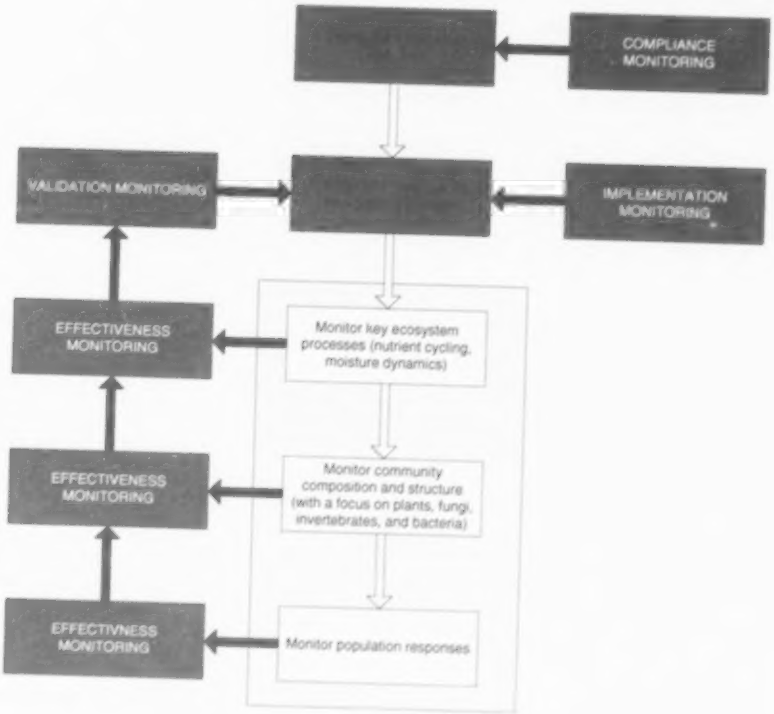
COMPLIANCE MONITORING
VALIDATION MONITORING
IMPLEMENTATION MONITORING
EFFECTIVENESS MONITORING
Monitor key ecosystem processes (nutrient cycling, moisture dynamics)
EFFECTIVENESS MONITORING
Monitor community composition and structure (with a focus on plants, fungi, invertebrates, and bacteria)
EFFECTIVNESS MONITORING
Monitor population responses

Figure B.1 Illustrates the four types of monitoring and their relation to reclamation activities and the monitoring program. Monitoring directly relevant to revegetation outcomes is conducted within the shaded box.

Table A.3 Nuisance plant species

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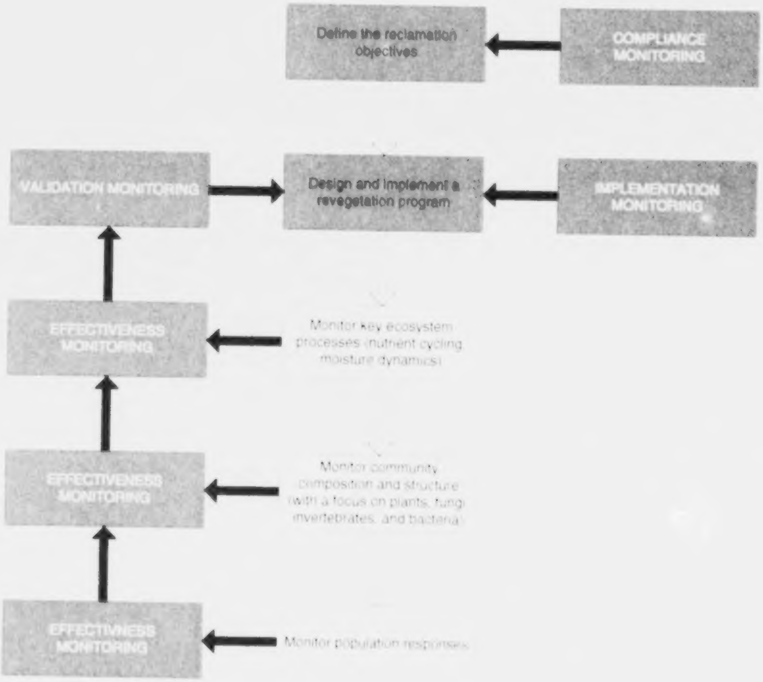
Define the reclamation objectives
COMPLIANCE MONITORING
VALIDATION MONITORING
Design and implement a revegetation program
IMPLEMENTATION MONITORING
EFFECTIVENESS MONITORING
Monitor key ecosystem processes (nutrient cycling, moisture dynamics)
EFFECTIVENESS MONITORING
Monitor community composition and structure (with a focus on plants, fungi, invertebrates, and bacteria)
EFFECTIVNESS MONITORING
Monitor population responses

Figure B.1 **Illustrates the four types of monitoring and their relation to reclamation activities and the monitoring program. Monitoring directly relevant to revegetation outcomes is conducted within the shaded box.**

Development of a monitoring/evaluation framework should include the following steps (after Bancroft et al. 2007):

1. Clearly define the reclamation objectives (as per directives in Section 1).
2. Build the indicators and performance criteria. This will provide information on change in the reclaimed ecosystem, and whether that change is consistent with the reclamation objectives (See Section 5).
3. Design and plan data collection.
4. Implement a data collection program and evaluate results against the performance criteria.
5. If necessary, implement remediation efforts, modify expected outcomes, and/or change subsequent activities.

Within the context of reclamation, a criterion represents a category of conditions or processes by which the success of a given set of reclamation practices is assessed. In a broad sense, criteria represent the goals and objectives of a reclamation project (CCFM 1995). Indicators constitute the elements of a criterion that will be used to assess the state of a reclaimed site, progress over time, and inform future decision making (Hickey and Innes 2005). Finally, measures are those aspects of an indicator that can actually be quantified.

The TSG evaluated the report entitled *Proposed Criteria and Indicators of Ecosystem Function for Reclaimed Oil Sands Sites* (CEMA 2006) to define the indicators and measures selected for evaluation in Section 5. The indicators not selected for evaluation were categorized as soft indicators requiring further development. Section B.2 provides a summary of the current status of the indicators evaluated by TSG and recommendations for further developing the indicators. Some general considerations regarding stand development following a disturbance are provided in Section B.3 to assist in developing trend-based monitoring programs. Additional information regarding the intermediate category measures of the indicator plant community composition (defined in Section 5) is provided in Section B.4. These intermediate category measures are parameters to be monitored to establish trend-based effectiveness monitoring datasets.

Indicator Selection

Ideally, a suite of indicators should be derived from all levels in the hierarchy (see Figure B.1) to ensure that reclamation activities are indeed consistent with long-term objectives. For example, ingress of non-native plant species can result in enhanced rates of carbon and nitrogen cycling (Liao et al. 2008), but native species composition may be compromised. If the latter is not included as an indicator variable, then non-native species ingress would be recognized only in terms of its benefit to key ecosystem processes. This example illustrates several important properties of any indicator program, namely:

(a) That a suite of indicators are necessary to ensure all aspects of the reclaimed ecosystem are represented;
(b) Different indicators may provide contradictory results; and
(c) In recognition of this inherent trade-off, successful reclamation may constitute a balance between indicators.

A vast number of potential indicators are available for use in oil sands reclamation. For example, Hickey and Innes (2005) identified over 3000 indicators in use under various programs around the world. Howevfer, a critical feature of forestry-based indicators is the implicit assumption that most (if not all) of the basic ecosystem functions and services are in place at the time management activities are implemented. This makes it possible to quantify these functions and services, at least in principle, and derive appropriate standards and thresholds. Thresholds represent the boundary or range of conditions that define sustainability limits for the resource in question, and when deviations are large enough to warrant management intervention. Application of the criteria and indicator approach to open-pit mining involves a very different kind of problem. As a consequence of mining activities, the basic attributes of an ecosystem (structure, function, complexity, and interconnectedness) have initially largely been removed. Hence, from a reclamation perspective, management goals are not oriented towards maintaining some condition but to reclaiming ecosystem processes and services to a level similar to undisturbed ecosystems, within a reasonable time scale.

Table B.1 provides the list of indicators and the associated measures selected by the TSG for assessing reclamation success. The hard measures are shaded in grey to indicate these measures have thresholds defined in the corresponding sections of Section 5 of the Revegetation Manual. The intermediate category measures are discussed further in Section B.4, and are trend-based effectiveness monitoring parameters for which thresholds are not defined, however, monitoring of these measures is recommended.

Table B.1 Indicators identified in Section 5 of the Revegetation Manual

Indicator	Measure	Category	Method
Plant Community Composition	Number of characteristic species	Hard measure	Section 5.3.3
	Restricted weeds	Hard measure	Section 5.3.3
	Species diversity	Intermediate measure	Appendix B, Section B.4
	Species richness	Intermediate measure	Appendix B, Section B.4
	Species evenness	Intermediate measure	Appendix B, Section B.4
	Abundance	Intermediate measure	Appendix B, Section B.4
	Alien species	Intermediate measure	Appendix B, Section B.4
Ecosystem Net Primary Productivity	Site index	Hard measure	Section 5.4
Salinity	Electrical conductivity	Heard measure	Section 5.5

▨ Shading denotes hard indicators and measures for which thresholds are defined in Section 5

Several indicators were designated by the TSG to be considered soft indicators because the indicator is either addressed by other reclamation manuals (e.g., soil nitrogen and the LCCS) or insufficient knowledge is available to define a threshold or a trend-based protocol for evaluating the indicator (Table B.2). Many of the soft indicators are currently under evaluation in regional research projects (e.g., CONRAD ERRG) or parameters monitored on the TSG long-term plot network. As knowledge is accumulated, the soft indicators will be evaluated further and where appropriate, development of trend-based protocols or thresholds will be initiated.

Table B.2 Indicators identified by RMTG as soft indicators requiring further evaluation

Indicator	Status
Soil erosion	Will be detected via performance measures. Potentially conduct a separate erosion study at a landscape level.
Soil microbial diversity	Requires further development. Possibly conduct research in the context of decomposition rates or mineralizable nitrogen.
Soil faunal diversity	Not a routine measurement. Research underway by CONRAD ERRG.
N-fixing symbionts	Not a routine measurement. Possibly conduct research in the context of nitrogen deposition.
Forest floor turnover/ development	Method to be developed for implementation on the long-term plot network beginning in 2010.
Litter quality	Requires further development. Investigate further if observations of forest floor development trigger questions.
Soil nutrients	Monitor total nitrogen and nitrogen forms, nitrogen release, phosphorus and base cations, as per soil monitoring protocol on the long-term plot network.
Mycorrhizal diversity	Investigate further if observations trigger questions.
Snags	Distinguish between snags from reclamation material and from natural vegetation.
Coarse woody debris	Distinguish between coarse woody debris from reclamation material and from natural vegetation.
Foliar nutrients	Method to be developed for implementation on long-term plot network in 2010.

▨ Shading denotes soft indicators for which thresholds are under development or currently exist to monitor these indicators on the TSG long-term plot network.

General considerations

Numerous indices have been developed to facilitate comparison between communities in their structural and compositional attributes but no single index can be considered as the definitive measure. Hence, applying a broad suite of indicators is important. In addition to the attributes derived from living biomass, deadwood material is also a critical component of plant communities (see Harmon et al. 1986, for a review) and its status should be monitored accordingly. Another important consideration is to ensure comparisons are restricted to sites with similar abiotic features. Diversity indices for communities on dry sites, for example, will be expected to differ significantly from communities established on moist sites.

Interpretation of monitoring results has its challenges. First, there is uncertainty in the process by which understory establishment occurs. According to the initial floristics model (Egler 1954), species composition following stand-replacing disturbance is determined by the propagules that existed on the site at the time of the disturbance and those that arrive early in the process of stand development. Any change in community composition over time is the result of differential growth and development of extant species rather than from recruitment of additional species. Under the initial floristics model, community composition on reclaimed sites should therefore be representative of the range of species observed in both young and mature natural stands.

The alternative hypothesis is the relay floristic model whereby community development is characterized by well-defined seral stages (Egler 1954). Following a stand-replacing disturbance, seral development begins with pioneer species (shade intolerant, usually annual, with small seeds and abundant seed crops) that in time are replaced by perennial species with successively greater shade tolerance and larger seeds, culminating in a relatively stable community of climax species. In this case, the assemblage of species characteristic of young natural stands should be similar to the complement of species occupying the early seral environment of a newly reclaimed site, and very different from the species found in mature natural sites.

From a chronosequence analysis, Gelhorn and Downing (2005) and Lee et al. (1995) concluded that vascular plants species in mixedwood stands tended to support the initial floristics model (see also Bergeron 2000). Peters et al. (2006), however, concluded that white spruce regeneration did not readily fit either model; few sites were strongly dominated by either initial or delayed regeneration while many showed a relatively even mix of both. In contrast, the diversity and abundance of nonvascular species (i.e., mosses, lichens, liverworts, and fungi) may increase as stands age (thereby displaying a relay floristics pattern), probably because of an increase in the abundance of downed woody material (Crites and Dale 1995, 1998). The woody debris constitutes important habitat for non-vascular species.

The issue of whether understory establishment is best explained by the initial floristics or the relay floristics model has important implications for the revegetation program. If the initial floristics model predominates then both young and mature natural stands are suitable analogues for deriving an appropriate mix of species for planting and developing benchmarks of performance (though with additional caveats: see below). Under the relay floristics model, in contrast, species undergo a serial replacement with the result that the floristic composition in mature stands is very dissimilar to that of young stands. Therefore, only the young stands will be an appropriate analogue for reclamation.

A second challenge with respect to interpreting monitoring results arises due to the inherent patterns in community composition and abundance that occur during stand development. Mixedwoods generally proceed through four stages of stand development:

- Stand initiation,
- Stem exclusion,
- Canopy transition (also called understory reinitiation; Oliver and Larson 1990), and
- Gap dynamics (Chen and Papadiouk 2002).

Stand initiation follows a major disturbance (or in the case of oil sands reclamation, when the capping material has just been laid down and is suitable for plant establishment). A key feature of this stage is that growing space is generally not limiting, at least initially. Following the occurrence of a major disturbance, plant species usually establish quickly, along with a rapid population increase in pioneer and clonal species (if the latter were present pre-disturbance). Dominant species at this stage tend to be shade-intolerant and have high inherent growth rates. If newly reclaimed sites develop in a similar pattern to naturally disturbed sites, sequential measures of species composition and abundance should demonstrate an increase through the stand initiation phase.

As vegetation becomes established and the tree canopy reaches full closure, the stem exclusion stage begins. This can occur in as little as 7-10 years in well-stocked aspen stands growing on fertile sites; it may take decades in sites limited by nutrients or moisture. Understory light levels are very low during stem exclusion, consequently overall understory abundance declines and shade-intolerant species may be extirpated. Recruitment of new understory species is rare at this stage though shade-tolerant species may increase in density. These conditions should be reflected in a decline in measures of abundance and community composition. The canopy transition (understory reinitiation) stage occurs several decades following stem exclusion,earlier in dry versus mesic sites. Understory light levels increase once again during this stage because the shade-intolerant canopy dominants start to age and die. This leads to resurgence in understory plant abundance and diversity, particularly amongst shade tolerant species, that continues into the gap dynamics phase.

These phases in stand development highlight the dynamic nature of abiotic factors and the interaction of these factors with the plant community composition. A summary of anticipated trends in measures of plant community composition and abundance is provided in Table B.3. Assessing the status of a particular indicator of community structure and composition on a reclaimed site will require multiple measurements and cannot be evaluated independently of the stage in stand development.

Table B.3 **Stages in boreal mixedwood stand development and their relationship to measures of plant community abundance and composition**

Stage	Age range (y)	Abundance	Composition	Shade Group[1]
Stand initiation	0 - 20	Increasing	Increasing	SI
Stem exclusion	7 - 35	Decreasing	Decreasing	ST
Canopy transition	30 - 100	Increasing	Increasing	ST
Gap phase	70 +	Increasing	Stable	ST and SI

[1] SI - shade intolerant, ST - shade tolerant

Measures of plant community composition

Section 5.3 of the Revegetation Manual defined the following four intermediate category measures of plant community composition:

- Species richness,
- Species diversity,
- Eevenness, and
- Abundance.

Species richness

Species richness is the number of different species in a particular area (S). The Revegetation Manual defines the number of characteristic species for a site type as a minimum threshold for achieving reclamation success (Section 5.3.3). Species richness on reclaimed sites will need to be, at a minimum, equivalent to the threshold characteristic species value.

Species diversity

Species diversity is derived from species richness weighted by some measure of abundance, such as number of individuals or biomass. Species diversity is commonly calculated using the Shannon diversity index (H):

$$H= - (\sum (\rho i \ln\rho i)) ,$$

where ρi is the proportion of the total number of individuals expressed as a proportion of the total number of species for all species in the ecosystem or plot. The product of ρi and $\ln\rho i$ (the natural log of ρi) for each species is summed, and multiplied by -1 to calculate H.

Species evenness

Species evenness (E) is the relative abundance with which each species is represented in an area. An ecosystem in which all the species are represented by the same number of individuals has high species evenness. An ecosystem in which some species are represented by many individuals, and other species are represented by very few individuals, has low evenness. The species evenness index (E) is calculated as:

$E=H/Hmax$,

where Hmax is the maximum possible value of H, and is equivalent to lnS, thus $E=H/\ln S$. For example, in a community with 10 species (S) in which the species contain equal numbers of individuals, $\rho = 0.1$ for each species. In a community with 10 species in which one species has 90% of the individuals, $\rho = 0.9$ for the dominant species, and $\rho = 0.01$ for the other nine species. From these values, H and E can now be determined. See Gibbs et al., (1998) and Magurran (1998) for discussion and further examples.

Abundance

Abundance is the relative representation of a species in a sample plot. Abundance can be quantified using destructive or non-destructive methods. Destructive methods, such as quantifying the biomass of understory vegetation requires considerable time and effort. Non-destructive methods have been developed that are practical to implement and particularly suitable for monitoring change in biomass over time within the same sample plot. Percent cover is one such method that has been widely used to characterize vegetation. Furthermore, there is a well-documented relationship between percent cover and aboveground biomass. For example, in boreal coniferous forests, percent cover is a good indicator for estimating above ground biomass of lichens, bryophytes, herbs, grasses, and dwarf shrubs in upland forests (Muukkonen et al., 2006).

Two factors need to be considered when evaluating percent cover. First, cover should be evaluated separately for each vegetation layer to reflect the fact that the understory is typically organized into several horizontal layers. Secondly, percent cover is estimated qualitatively and there can be considerable variation between observers in its estimate (Hermy 1988). Therefore, care should be taken to document estimation procedures thoroughly and to ensure results are consistent among observers.

A summary of richness, diversity, evenness and abundance, including sampling protocol is provided in Table B.4.

Table B.4 Measures associated with the indicator plant community composition

Measure	Unit	Min/Max Values (Targets)/Expected Trends	Methodology	Interpretation	Frequency of Data Collection
Richness	No. of species	See Table 5-3 in Section 5.3.3 of Revegetation Manual	Use existing plot data or establish new plots; organize by site type (e.g., moist rich, dry poor)	Comparable numbers of characteristic species.	Every 5 years
Shannon diversity index (H)	No units	To be determined	Use existing plot data or establish new plots; organize by site type (e.g., moist rich, dry poor)	Comparable index values, when taken together with a review of actual species occurring at reclaimed and native sites, indicate similar communities and probably similar ecological functional states.	Every 5 years
Evenness	No units	To be determined	Use existing plot data or establish new plots; organize by site type (e.g., moist rich, dry poor)	Comparable index values, when taken together with a review of actual species occurring at reclaimed and native sites, indicate similar communities and probably similar ecological functional states.	Every 5 years
Abundance	Percent cover	To be determined	Use existing plot data or establish new plots; organize by site type (e.g., moist rich, dry poor).	Good measure for processes associated with ecosystem function and resilience	Every 5 years

Alien Species

Noxious and nuisance weeds, as defined by the *Weed Control Act* should be tracked over time on all reclamation polygons (see Appendix A for lists of noxious and nuisance weeds). Data pertaining to noxious and nuisance weeds should be gathered in conjunction with the measures of plant community composition and evaluated as a subset to determine the species richness, diversity, evenness and abundance of alien plant species.

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Appendix C—Soil Salinity

Introduction

Diverse plant communities can thrive in upland and riparian areas where surface soil salinity exceeds 4 dS/m, but these plant communities are significantly different from equivalent non-saline boreal landscapes (Purdy et al. 2005). As a result, on any reclaimed environments in which surface soils exceed or are anticipated to exceed 4 dS/m, different plant communities should be targeted for reclamation purposes than would otherwise be anticipated from standard ecosite classification.

In particular, lower-slope positions in saline-sodic overburden dump and tailings landforms are likely to be receiving environments for saline groundwater. In saline landscapes, these slope positions are dominated by wet-meadow vegetation as the high water table contributes to surface soil salinization, which precludes the development of treed vegetation (Close et al., 2007). Thus, some ecosites, such as f, g and h, may be difficult to establish in landforms possessing saline groundwater, where the salinity approaches the surface and is at levels that exceed the tolerance of the species associated with those ecosites. Note that this discussion is particularly relevant to surface or topsoil salinity - high subsoil salinity alone is unlikely to result in shifts in plant community composition (Purdy et al., 2005; Close 2007).

Where boreal trees do occur in natural saline landscapes, surface soil salinity is typically lower than 4 dS/m, though subsurface soil salinity can be much higher (> 20dS/m). In natural sites affected by salinity, productivity of tree species is typically low and the majority of stands would be classified as non-commercial with low site index values (Close 2007). For reclamation purposes, forested habitat can be established over reclaimed landforms anticipated to be saline; however, there are limits to acceptable surface soil salinity (e.g., 4 dS/m) for the establishment and growth of tree species, and expectations for productive stands or commercial forestry would be unrealistic.

Naturally occurring saline landscapes in the boreal forest are characterized by five vegetation community types: dry meadow, wet meadow, flooded, shrub and forest. The soil salinity and pH of the community types are presented in Table C.1 and the EC is shown in Figure C.1.

Table C.1 **Mean soil salinity and pH at two depths (10-20, 80-100 cm) for the five vegetation communities in saline landscapes**

Community	N	Ca^{2+}		Mg^{2+}		K^+		Na^+		Cl^-		SO_4^{2-}		SAR		pH	
		10-20	80-100	10-20	80-100	10-20	80-100	10-20	80-100	10-20	80-100	10-20	80-100	10-20	80-100	10-20	80-100
Dry meadow	15	454	409	222	232	24	14	3292	3941	4461	5533	1165	1522	35.8	48.3	8.3	8.3
Wet meadow	15	649	636	271	208	33	24	6673	8068	9369	9697	2126	2172	59.4	70.2	7.9	8.2
Flooded	8	442	558	313	327	38	29	3457	4240	4652	6629	2088	2340	32.8	41.9	7.8	8.2
Shrub	11	249	424	99	209	10	13	1158	3296	1417	5046	507	1241	18.0	38.8	7.9	8.3
Forest	12	285	578	49	210	12	11	300	2522	445	3496	216	1220	4.5	27.9	7.7	8.5

N = number of plots

Cation and anion values are expressed in ppm

Source: Data compiled from Purdy et al. 2005.

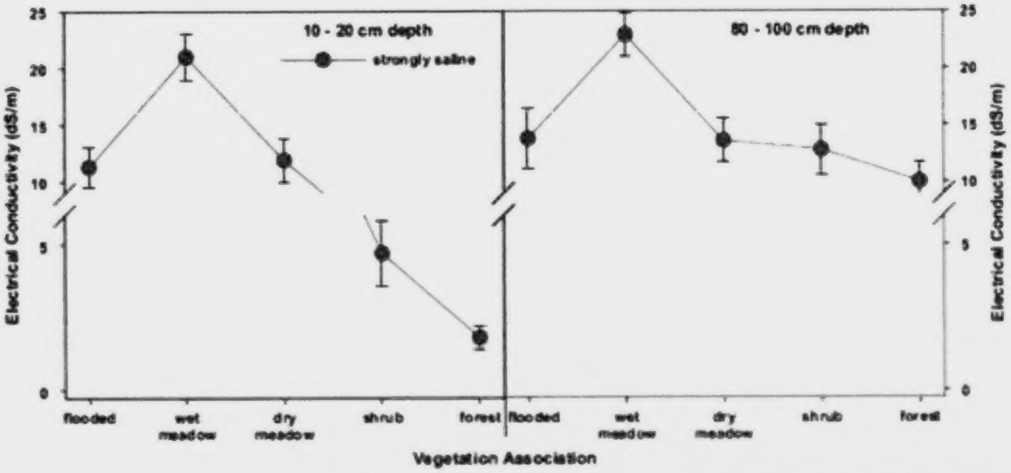

Figure C.1 **Trends in soil-saturated paste EC for five community types along a gradient from flooded wetlands to upland forest in Alberta's boreal forest. Mean values (±SE) are expressed for each community type**

The following tables present species lists for the five saline communities identified by Purdy et al. (2005), including dry meadow (Table C.2), wet meadow (Table C.3), flooded (Table C.4), shrub (Table C.5) and forest (Table C.6). The species lists are derived for saline landscapes from the dataset compiled for CEMA as part of the "Forest Productivity in Naturally Saline Landscapes of Alberta's Boreal Forest" research study (Close et al. 2007). Differences in plant communities between saline and nonsaline landscapes are predominantly in response to a gradient in soil salinity (Purdy et al. 2005). Species with a prominence of 5 or greater were included in the species lists for each community.

Prominence was calculated by: Prominence = $\sqrt{\%frequency x \% cover}$

Dry Meadow Community

The dry meadow community is only present in landscapes where surface soil salinity is high enough to limit the growth of many boreal forest species. At a similar topographic position in nonsaline study areas, shrub or forest vegetation would be present (Purdy et al. 2005).

Many of the species identified in the dry meadow community (Table C.1) are uncommon in the boreal forest and are more typical of the dry mixed grass subregion of southern Alberta where saline soils are common. The selection of the dry meadow species community would be limited to landforms where salinity >4 dS/m and topographic position would impede the establishment of other plant communities.

Table C.2 Species list with salinity tolerance (H for high tolerance EC>7.5; M for medium 4<EC<7.5; L for low tolerance EC<4; N/A for no data), including prominence for the edatopic position Dry Meadow in saline site condition (104 species were found from 15 plots)

Scientific name	Common Name	Salinity tolerance[1]	Prominence[2]
Tree Stratum			
Picea glauca	white spruce	H	7.07
Shrub Stratum			
Juniperus horizontalis	creeping juniper	N/A	9.31
Rosa acicularis	prickly rose	H	18.26
Salix bebbiana	beaked willow	N/A	5.77
Symphoricarpos albus	snowberry	H	11.55
Symphoricarpos occidentalis	buckbrush	N/A	8.16
Forb Stratum			
Achillea millefolium	common yarrow	N/A	13.54
Antennaria parvifolia	small-leaved everlasting	N/A	15.81
Artemisia tilesii	Herriot's sagewort	N/A	7.07
Aster ericoides	tufted white prairie aster	N/A	16.83
Aster hesperius	western willow aster	N/A	10.00
Aster laevis	smooth aster	N/A	5.77
Aster pauciflorus	few-flowered aster	N/A	8.16
Astragalus striatus	ascending purple milk vetch	N/A	5.77
Castilleja raupii	purple paintbrush	N/A	5.77
Cerastium arvense	field mouse-ear chickweed	N/A	7.07
Chenopodium rubrum	red goosefoot	N/A	7.07
Cicuta maculata	water-hemlock	N/A	8.16
Cicuta virosa	narrow-leaved water-hemlock	N/A	7.07
Comandra umbellata	bastard toadflax	N/A	11.55
Erigeron philadelphicus	Philadelphia fleabane	N/A	5.77
Fragaria virginiana	wild strawberry	M	8.16
Galium boreale	northern bedstraw	N/A	15.81
Geum triflorum	three-flowered avens	N/A	7.07
Glaux maritima	sea milkwort	H	20.82
Grindelia squarrosa	gumweed	H	13.54
Hedysarum alpinum	alpine hedysarum	N/A	8.16

Scientific name	Common Name	Salinity tolerance[1]	Prominence[2]
Lactuca pulchella	common blue lettuce	N/A	5.77
Mentha arvensis	wild mint	N/A	7.07
Plantago eriopoda	saline plantain	N/A	31.36
Potentilla anserina	silverweed	N/A	9.13
Primula incana	mealy primrose	N/A	14.14
Ranunculus cymbalaria	seaside buttercup	N/A	7.07
Salicornia europaea	**samphire**	**N/A**	**5.77**
Sisyrinchium montanum	common blue-eyed grass	N/A	5.77
Smilacina stellata	star-flowered Solomon's-seal	N/A	11.55
Solidago simplex ssp simplex	mountain goldenrod	N/A	7.07
Sonchus uliginosus	smooth perennial sow-thistle	N/A	19.58
Spergularia salina	**salt-marsh sand spurry**	**H**	**8.16**
Stachys palustris	marsh hedge-nettle	N/A	7.07
Stellaria longipes	long-stalked chickweed	N/A	7.07
Suaeda calceoliformis	**western sea-blite**	**N/A**	**5.77**
Vicia americana	wild vetch	M	9.13
Grass Stratum			
Agrostis scabra	rough hair grass	N/A	5.77
Calamagrostis inexpansa	northern reed grass	H	26.14
Calamagrostis stricta	narrow reed grass	N/A	10.00
Carex aurea	golden sedge	N/A	7.07
Carex praticola	meadow sedge	N/A	12.25
Deschampsia caespitosa	tufted hair grass	N/A	16.33
Distichlis stricta	**salt grass**	**H**	**16.83**
Elymus trachycaulus ssp trachycaulus	slender wheat grass	H	20.00
Festuca saximontana	Rocky Mountain fescue	N/A	8.16
Hierchloe odorata	sweet grass	H	21.21
Hordeum jubatum	foxtail barley	H	28.28
Juncus balticus	wire rush	N/A	10.80
Koelaria macrantha	June grass	N/A	7.07
Muhlenbergia richardsonis	mat muhly	N/A	10.80
Poa arida	**plains bluegrass**	**N/A**	**5.77**
Poa interior	**inland bluegrass**	**N/A**	**7.07**
Poa palustris	fowl bluegrass	N/A	8.16
Puccinellia nuttalliana	**Nuttall's salt-meadow grass**	**H**	**15.28**
Spartina gracilis	**alkali cord grass**	**H**	**8.16**
Triglochlin maritima	seaside arrow-grass	H	13.54

[1] Salinity tolerance codes obtained from Howat 2000

H - high tolerance EC>7.5 dS/m

M - medium tolerance 4 dS/m < EC < 7.5 dS/m

L - low tolerance EC < 4 dS/m

N/A - salinity tolerance value not determined in Howat 2000

[2] Prominence values calculated were calculated by combination of vegetation type and soil salinity level

denotes species for which fact sheets are available in Appendix F

▨ Denotes species uncommon to the boreal forest

Wet Meadow Community

Wet meadows in saline landscapes are occasionally dominated by species uncommon in the boreal forest. In nonsaline landscapes, wet meadow communities are similar to the sedge meadow communities typically dominated by *Calamagrostis canadensis* or *Carex utriculata* and *Carex aquatilus* (Purdy et al. 2005).

Table C.3 Species list with salinity tolerance (H for high tolerance EC>7.5; M for medium 4<EC<7.5; L for low tolerance EC<4; N/A for no data) including prominence for the edatopic position Wet Meadow in saline site condition (54 species were found from 15 plots)

Scientific name	Common Name	Salinity tolerance[1]	Prominence[2]
Shrub Stratum			
Salix discolor	pussy willow	N/A	7.07
Forb Stratum			
Aster borealis	marsh aster	N/A	5.77
Aster ericoides	tufted white prairie aster	N/A	9.13
Aster hesperius	western willow aster	N/A	9.13
Aster pauciflorus	few-flowered aster	N/A	10.00
Chenopodium berlandieri	Berlandier goosefoot	N/A	5.77
Chenopodium rubrum	red goosefoot	N/A	16.33
Cicuta maculata	water-hemlock	N/A	5.77
Cicuta virosa	narrow-leaved water-hemlock	N/A	7.07
Galium trifidum	sweet-scented bedstraw	N/A	5.77
Glaux maritima	sea milkwort	H	18.26
Plantago eriopoda	saline plantain	N/A	23.45
Plantago maritima	sea-side plantain	H	5.77
Polygonum ramosissimum	bushy knotweed	N/A	8.16
Potentilla anserina	silverweed	N/A	10.00
Ranunculus cymbalaria	seaside buttercup	N/A	5.77
Salicornia europaea	samphire	N/A	16.33
Smilacina stellata	star-flowered Solomon's-seal	N/A	7.07
Sonchus uliginosus	smooth perennial sow-thistle	N/A	20.49
Spergularia salina	salt-marsh sand spurry	H	16.33
Suaeda calceoliformis	western sea-blite	N/A	12.91
Vicia americana	wild vetch	M	7.07
Grass Stratum			
Calamagrostis inexpansa	northern reed grass	H	16.33
Carex atherodes	awned sedge	H	12.91
Distichlis stricta	salt grass	H	9.13
Elymus trachycaulus ssp trachycaulus	slender wheat grass	H	8.16
Hordeum jubatum	foxtail barley	H	29.15
Juncus balticus	wire rush	N/A	10.00
Puccinellia nuttalliana	Nuttall's salt-meadow grass	H	46.19
Scirpus paludosus	prairie bulrush	N/A	5.77
Scolochloa festucacaea	spangletop	N/A	31.62

Scientific name	**Common Name**	**Salinity tolerance[1]**	**Prominence[2]**
Spartina gracilis	alkali cord grass	H	8.16
Triglochlin maritima	seaside arrow-grass	H	21.60

[1] Salinity tolerance codes obtained from Howat 2000

H - high tolerance EC>7.5 dS/m

M - medium tolerance 4 dS/m < EC < 7.5 dS/m

L - low tolerance EC < 4 dS/m

N/A - salinity tolerance value not determined in Howat 2000

[2] Prominence values calculated were calculated by combination of vegetation type and soil salinity level

denotes species for which fact sheets are available in Appendix F

▨ Denotes species uncommon to the boreal forest

Flooded Community

Flooded communities in saline landscapes are also occasionally dominated by species uncommon in the boreal forest. In nonsaline landscapes, the flooded communities are similar to the marsh communities typically dominated by *Typha latifolia* or *Scirpus validus* (Purdy et al. 2005).

Table C.4 **Species list with salinity tolerance (H for high tolerance EC>7.5; M for medium 4<EC<7.5; L for low tolerance EC<4; N/A for no data) including prominence for the edatopic position Flooded in saline site condition (37 species were found from 8 plots)**

Scientific name	Common name	Salinity tolerance[1]	Prominence[2]
Shrub Stratum			
Alnus viridis	green alder	L	5.59
Rubus ideaus	wild red raspberry	L	5.59
Rubus pubescens	dewberry	N/A	5.59
Salix planifolia	flat-leaved willow	N/A	9.68
Forb Stratum			
Aster hesperius	western willow aster	N/A	7.91
Chenopodium rubrum	red goosefoot	N/A	5.59
Chenopodium salinum	oak-leaved goosefoot	N/A	5.59
Cicuta maculata	water-hemlock	N/A	6.12
Epilobium palustre	marsh willowherb	N/A	5.59
Equisetum arvense	common horsetail	N/A	5.59
Erigeron philadelphicus	Philadelphia fleabane	N/A	11.18
Galium trifidum	small bedstraw	N/A	7.91
Mentha arvensis	wild mint	N/A	17.68
Petasites frigidus var sagittatus	arrow-leaved coltsfoot	N/A	5.59
Potentilla anserina	silverweed	N/A	5.59
Ranunculus abortivus	small-flowered buttercup	N/A	5.59
Ranunculus cymbalaria	seaside buttercup	N/A	7.91
Ranunculus scleratus	celery-leaved buttercup	N/A	6.61
Rumex occidentalis	western dock	N/A	5.59
Rumex triangulivalis	narrow-leaved dock	N/A	6.12
Scuttelaria galericulata	marsh skullcap	N/A	12.50
Sonchus uliginosus	smooth perennial sow-thistle	N/A	14.79
Stachys palustris	marsh hedge-nettle	N/A	7.91
Suaeda calceoliformis	western sea-blite	N/A	5.59
Grass Stratum			
Carex aquatilus	water sedge	N/A	15.81
Carex atherodes	awned sedge	H	30.10
Eleocharis palustris	creeping spike-rush	N/A	5.59
Hordeum jubatum	foxtail barley	H	5.59
Phalaris arundinacea	reed canary grass	H	5.59

Scientific name	Common name	Salinity tolerance[1]	Prominence[2]
Puccinellia nuttalliana	Nuttall's salt-meadow grass	H	13.69
Scolochloa festucacaea	spangletop	N/A	46.44
Scirpus paludosus	prairie bulrush	N/A	34.00
Schoenoplectus tabernaemontani	common great bulrush	N/A	21.65
Triglochlin maritima	seaside arrow-grass	H	11.18
Triglochlin palustris	slender arrow-grass	N/A	5.59
Typha latifolia	common cattail	N/A	31.12

[1] Salinity tolerance codes obtained from Howat 2000

H - high tolerance EC>7.5 dS/m

M - medium tolerance 4 dS/m < EC < 7.5 dS/m

L - low tolerance EC < 4 dS/m

N/A - salinity tolerance value not determined in Howat 2000

[2] Prominence values calculated were calculated by combination of vegetation type and soil salinity level

denotes species for which fact sheets are available in Appendix F

▨ Denotes species uncommon to the boreal forest

Shrub Community

The shrub understory of the saline landscapes is comprised of understory species common within the boreal forest in addition to some species associated with the dry meadow communities. The presence of different species of *Salix* in saline and nonsaline landscapes may reflect some differences in tolerance to salinity (Purdy et al. 2005).

Table C.5 **Species list with salinity tolerance (H for high tolerance EC>7.5; M for medium 4<EC<7.5; L for low tolerance EC<4; N/A for no data) including prominence for the edatopic position Shrub in saline site condition (110 species were found from 11 plots)**

Scientific name	Common name	Salinity tolerance[1]	Prominence[2]
Tree Stratum			
Betula glandulosa	bog birch	M	22.36
Betula papyrifera	white birch	M	9.53
Picea glauca	white spruce	H	21.43
Populus tremuloides	aspen	H	9.53
Shrub Stratum			
Alnus viridis	green alder	L	19.66
Amelanchier alnifolia	saskatoon	H	9.77
Eleagnus commutata	silverberry	N/A	9.53
Juniperus horizontalis	creeping juniper	N/A	11.68
Ribes lacustre	bristly black currant	N/A	10.87
Ribes oxycanthoides	northern gooseberry	N/A	6.03
Ribes triste	wild red currant	N/A	6.74
Rosa acicularis	prickly rose	H	26.54
Rubus ideaus	wild red raspberry	L	15.81
Rubus pubescens	dewberry	N/A	11.68
Salix bebbiana	beaked willow	N/A	26.54
Salix discolor	pussy willow	N/A	15.08
Salix glauca	smooth willow	N/A	9.53
Salix pseudomonticola	false mountain willow	N/A	6.74
Salix scouleriana	Scouler's willow	N/A	8.26
Sheperdia canadensis	Canada buffaloberry	H	17.19
Symphoricarpos albus	snowberry	H	15.08
Symphoricarpos occidentalis	buckbrush	N/A	14.30
Forb Stratum			
Achillea millefolium	common yarrow	N/A	15.08
Antennaria parvifolia	small-leaved everlasting	N/A	15.08
Aster ciliolatus	Lindley's aster	N/A	6.74
Aster ericoides	tufted white prairie aster	N/A	15.08
Aster laevis	smooth aster	N/A	10.66
Astragalus striatus	ascending purple milk vetch	N/A	6.74
Campanula rotundifolia	harebell	N/A	6.74
Castilleja raupii	purple paintbrush	N/A	6.74
Comandra umbellata	bastard toadflax	N/A	10.66
Equisetum arvense	common horsetail	N/A	8.26
Erigeron philadelphicus	Philadelphia fleabane	N/A	6.74
Fragaria vesca	woodland strawberry	N/A	5.22

Scientific name	**Common name**	**Salinity tolerance[1]**	**Prominence[2]**
Fragaria virginiana	wild strawberry	M	11.68
Galium boreale	northern bedstraw	N/A	29.77
Geum triflorum	three-flowered avens	N/A	6.74
Glaux maritima	sea milkwort	H	9.53
Hedysarum alpinum	alpine hedysarum	N/A	11.68
Hieracium umbellatum	narrow-leaved hawkweed	N/A	6.74
Mentha arvensis	wild mint	N/A	6.74
Petasites frigidus var palmatus	palmate-leaved coltsfoot	N/A	9.53
Plantago eriopoda	saline plantain	N/A	19.66
Scuttelaria galericulata	marsh skullcap	N/A	8.26
Smilacina stellata	star-flowered Solomon's-seal	N/A	15.08
Solidaga canadensis	Canada goldenrod	H	12.61
Solidaga gigantea	late goldenrod	N/A	9.53
Solidago simplex ssp simplex	mountain goldenrod	N/A	15.81
Sonchus uliginosus	smooth perennial sow-thistle	N/A	14.30
Stachys palustris	marsh hedge-nettle	N/A	15.08
Thalictrum venulosum	veiny meadow rue	N/A	11.68
Urtica dioica	common nettle	N/A	5.22
Vicia americana	wild vetch	M	10.66
Grass Stratum			
Agrostis scabra	rough hair grass	N/A	8.26
Calamagrostis canadensis	bluejoint	H	26.97
Calamagrostis inexpansa	northern reed grass	H	16.51
Calamagrostis stricta	narrow reed grass	N/A	8.26
Carex atherodes	awned sedge	H	8.26
Carex aurea	golden sedge	N/A	9.53
Carex praticola	meadow sedge	N/A	15.81
Carex siccata	hay sedge	N/A	10.66
Deschampsia caespitosa	tufted hair grass	N/A	10.66
Elymus trachycaulus ssp trachycaulus	slender wheat grass	H	22.86
Festuca saximontana	Rocky Mountain fescue	N/A	10.66
Hierochloe odorata	sweet grass	H	10.66
Juncus balticus	wire rush	N/A	11.68
Koelaria macrantha	June grass	N/A	8.26
Poa interior	**inland bluegrass**	N/A	6.74
Poa palustris	fowl bluegrass	N/A	9.53
Triglochin maritima	seaside arrow-grass	H	6.74

[1] Salinity tolerance codes obtained from Howat 2000

H - high tolerance EC>7.5 dS/m

M - medium tolerance 4 dS/m < EC < 7.5 dS/m

L - low tolerance EC < 4 dS/m

N/A - salinity tolerance value not determined in Howat 2000

[2] Prominence values calculated were calculated by combination of vegetation type and soil salinity level

denotes species for which fact sheets are available in Appendix F

▨ Denotes species uncommon to the boreal forest

Forest Community

Upland boreal forest vegetation in saline landscapes where the EC in the upper soil (0-20 cm) is < 4 dS/m are similar in species composition to that found in nonsaline habitats. The deeper soils (80-100 cm) in the saline landscapes are quite saline (EC >10 dS/m) (Purdy et al. 2005).

Table C.6 Species list with salinity tolerance (H for high tolerance EC>7.5; M for medium 4<EC<7.5; L for low tolerance EC<4; N/A for no data) including prominence for the edatopic position Forest in saline site condition (77 species were found from 12 plots)

Scientific name	Common name	Salinity tolerance[1]	Prominence[2]
Tree Stratum			
Betula glandulosa	bog birch	M	7.91
Betula papyrifera	white birch	M	12.08
Picea glauca	white spruce	H	38.19
Populus balsamifera	balsam poplar	H	15.81
Populus tremuloides	aspen	H	41.33
Shrub Stratum			
Alnus viridis	green alder	L	9.13
Amelanchier alnifolia	saskatoon	H	27.39
Aralia nudicaulis	wild sarsaparilla	N/A	15.14
Arctostaphylos uva-ursi	common bearberry	L	7.91
Cornus stolonifera	red-osier dogwood	H	12.08
Corylus cornuta	beaked hazelnut	N/A	7.91
Juniperus horizontalis	creeping juniper	N/A	15.14
Linnaea borealis	twinflower	H	12.08
Ribes lacustre	bristly black currant	N/A	7.91
Ribes triste	wild red currant	N/A	13.69
Rosa acicularis	prickly rose	H	27.39
Rubus ideaus	wild red raspberry	L	15.81
Rubus pubescens	dewberry	N/A	15.14
Salix bebbiana	beaked willow	N/A	9.13
Salix discolor	pussy willow	N/A	11.18
Salix glauca	smooth willow	N/A	7.91
Sheperdia canadensis	Canada buffaloberry	H	24.58
Symphoricarpos albus	snowberry	H	23.72
Viburnum edule	low-bush cranberry	N/A	17.68
Forb Stratum			
Achillea millefolium	common yarrow	N/A	9.13
Aster laevis	smooth aster	N/A	7.91
Cornus canadensis	bunchberry	L	17.68
Epilobium angustifolium	common fireweed	H	6.45
Equisetum arvense	common horsetail	N/A	7.91
Fragaria virginiana	wild strawberry	M	18.37
Galium boreale	northern bedstraw	N/A	16.58
Galium triflorum	sweet-scented bedstraw	N/A	6.45

Scientific name	Common name	Salinity tolerance[1]	Prominence[2]
Geocaulon lividum	northern bastard toadflax	H	9.13
Hedysarum alpinum	alpine hedysarum	N/A	11.18
Lathyrus ochroleucus	cream-colored vetchling	N/A	6.45
Mertensia paniculata	tall lungwort	N/A	12.08
Mitella nuda	bishop's-cap	N/A	17.08
Plantago eriopoda	saline plantain	N/A	7.91
Pyrola asarifolia	common pink wintergreen	H	5.00
Pyrola chlorantha	greenish-flowered wintergreen	N/A	6.45
Pyrola grandiflora	arctic wintergreen	N/A	6.77
Smilacina stellata	star-flowered Solomon's-seal	N/A	7.91
Thalictrum venulosum	veiny meadow rue	N/A	12.91
Vicia americana	wild vetch	M	10.21
Grass Stratum			
Carex concinna	beautiful sedge	N/A	12.91
Carex praticola	meadow sedge	N/A	7.91
Elymus trachycaulus ssp *trachycaulus*	slender wheat grass	H	9.13
Leymus innovatus	hairy wild rye	N/A	13.69

[1] Salinity tolerance codes obtained from Howat 2000

H - high tolerance EC>7.5 dS/m

M - medium tolerance 4 dS/m < EC < 7.5 dS/m

L - low tolerance EC < 4 dS/m

N/A - salinity tolerance value not determined in Howat 2000

[2] Prominence values calculated were calculated by combination of vegetation type and soil salinity level

denotes species for which fact sheets are available in Appendix F

References

Close, EB. 2007. Forest productivity in naturally saline landscapes of Alberta's boreal forest M.Sc. thesis. University of Alberta, Edmonton AB.

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Howat, D.R. 2000. Acceptable salinity, sodicity and pH values for boreal forest reclamation. Alberta Environment, Environmental Sciences Division Rep. ESD/LM/00-2.

Macyk, T.M., Naeth, A., Purdy, B., Quideau, S., Welham, C. Leskiw, L., and C. Qualizza. 2006. Soil capping technology transfer phase 3: biology. Syncrude Canada Ltd., Ft. McMurray, AB: Fact sheet 33: Naturally saline boreal forest communities as models for reclamation of saline oil-sand tailings (Part II - plant community composition and diversity).

Purdy, BG; Macdonald, SE & Lieffers, VJ. 2005. Naturally Saline Boreal Communities as Models for Reclamation of Saline Oil Sand Tailings. Restoration Ecology 13: 667-677.

Appendix D—Wildlife Populations and Habitat Capability in the Oil Sands Region

D.1 Introduction to Wildlife Habitat Guidelines

This appendix is relevant to the wildlife habitat land use objective. The material presented combines and provides updates to Section 5 and Appendix J of the 1998 version of the Revegetation Manual. The updates were obtained from four main CEMA documents based on western science and/or traditional knowledge of wildlife habitat (see Section D.2). Additional information was gathered from regional wildlife experts at a symposium hosted by the Biodiversity and Wildlife Subgroup in January 2008.

This appendix should be used in conjunction with other reclamation documents such as the wetlands manual[1] and the shrub species review for reclaimed ecosites[2]. The premise inherent in these reviews and guidelines is that reclamation on oil sands leases requires an integrated approach from a suite of skilled specialists.

D.1.1 Wildlife Associations in the Oil Sands Region

The mixedwood boreal forest habitat dominating the landscape in the RMWB supports a rich, temperate zone assemblage of wildlife adapted to large country and exposed to a range of natural disturbances such as fire, insects and winter storms[3]. Anthropogenic disturbance is occurring in the oil sands region, principally from surface mining, SAGD, and conventional oil and gas development. The long-term effects of these anthropogenic disturbances on wildlife populations are not known. Climate change (or the presence of an extended dry, warm period) is also likely to result in range changes for many species inhabiting the boreal forest. Practicing adaptive management for wildlife in disturbed and reclaimed environments is a realistic approach, given the limited understanding of the cumulative nature of these changes.

The two key pillars at the base of most boreal food chains are vegetation and invertebrates. These must be present for the herbivores and most birds to survive. In turn, the herbivores and birds must be present for the predators to survive. Thus a discussion of wildlife must include consideration of vegetation and invertebrates. This message was clear during consultation with Elders regarding regional wildlife populations: what is removed must be put back for wildlife to return[4]. Such a broad discussion is beyond the scope of this appendix, but must occur elsewhere, in companion guidelines[5].

There are numerous herbivores in the region including large ungulates, small mammals and migratory and resident birds. Moose is the most common and widely distributed of the large herbivores. Other species present include woodland caribou, deer (mule and white-tailed), and wood bison. Deer may become more common if winters continue to lessen in severity and as more forest is cleared. Small mammal herbivores include snowshoe hare, squirrels (red and northern flying), chipmunks, beaver, muskrat, porcupine and as many as twelve species of mice, vole and shrew[6]. The collective biomass of these small animals is substantial and abundance of these species will have by far the greatest impact on sustainability of most predator populations in reclaimed environments.

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[1] Alberta Environment 2008

[2] Geographic Dynamics Corp 2002

[3] Foote 2003

[4] Garibaldi Heritage and Environmental Consulting 2006a

[5] Oil Sands Vegetation Reclamation Committee 1998; Golder Associates 2007; Alberta Environment 2008 as a start, but more guidance particularly on invertebrates is needed

Seed-eating birds, such as crossbills, chickadees, jays and finches, have an important ecological role as well, in establishment of vegetation in reclaimed or regenerating forests and wetlands. Grouse, or chickens, may in some instances be the dominant avian ground foragers in upland environments. Many waterbirds, particularly ducks but also gulls, cranes, swans, geese, grebes, loons and shorebirds, migrate through the region en route to the Peace - Athabasca Delta; however, low numbers remain over the summer, possibly due to a low density of large open waters in the region. The potential for aerial coverage of lakes and marshes to increase during aquatic reclamation of oil sands leases is considerable and may result in increased numbers of breeding waterfowl in future[7]. There are over 70 species of passerine birds in the region[8], some of which are insectivorous, and over half of which are neotropical migrants. Among the insectivores, there are seven woodpecker and five swallow species. Non-avian insectivores include five species of bat and three amphibians[8].

Predators' position at the top of the food chain leaves them vulnerable to the myriad of variables influencing population sizes of their prey. Black bears are mostly herbivores, but will kill young ungulates in the spring. Grizzly bears are rarely seen in the region. Coyotes, wolves, red fox, fisher, marten, wolverines and weasels are the dominant ground hunters within the region. Aerial hunters include twenty-four raptors (hawks and owls).

Monitoring all of these animals and extracting meaningful conclusions about habitat quality in reclaimed landscapes is not feasible. Thus, the SEWG in CEMA established a workable set of goals and priority species for use in evaluating reclamation for wildlife. Those goals and the corresponding choices for priority species are listed in Section D.2. These species form the basis for discussions of habitat requirements and guiding recommendations for reclamation in the remainder of this appendix.

D.1.2 Background Objectives

Reclamation of land and water for wildlife use can be achieved using a variety of planning approaches. Planning may be focused on a landscape (a lease site or a landform type), an ecosystem (e.g., riparian margins, wetlands, old growth upland forests) or on a species of wildlife (e.g., moose, black bear, muskrat). Landscape reclamation is broadly based on structural elements (e.g., slopes, aspects, elevations, plateaus, lowlands), whereas ecosystem reclamation is primarily concerned with functional or form elements (e.g., nutrient & water flows/cycles, thermal patterns, rates of production & decomposition, vegetation communities, species composition). Wildlife reclamation is often narrowly focused on species of interest, and may rely on intensive management techniques like captive breeding, reintroductions or translocations. In keeping with the premise of integration described above, this appendix was designed to enable planning for wildlife at landscape, ecosystem and species scales.

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[6] Bovar Environmental 1998

[7] Alberta Environment 2008

[8] Bovar Environmental 1998

The recommendations provided in this appendix are focused on large-scale reclamation, to address the needs of the surface mineable oil sands sector; however, some of the information may be applicable to reclamation of smaller or less impacted environments as well, such as SAGD well-pads.

D.1.3 Principles

The wildlife reclamation guidance provided in the appendix is based on the following principles derived from projects completed by the Biodiversity and Wildlife Subgroup between 2002 and 2006:

- Wildlife will be best served if the reclaimed landscape is designed to closely resemble the pre-disturbance landscape in terms of terrain, hydrology, soils, vegetation, and ecosite distribution.
- The establishment of species not normally present in the region is discouraged.
- Planning for reclaimed wildlife habitat begins at the disturbance phase of development. Soil handling and placement decisions made during mining will have significant influence over the eventual range of wildlife habitats that are possible on any given site.
- Species are interconnected through their habitat and habits, thus designing an environment for one will influence the suitability of that environment for another.
- Wildlife reclamation is inextricably linked to vegetation establishment and plant community succession.
- Vegetation must be established before herbivores will remain in a reclaimed landscape, and a prey-base of herbivores must be established before predators will remain.
- Many wildlife species in the northern boreal forest have large territory sizes or migrate, and many are sensitive to disturbance, particularly while rearing offspring; in such instances, reclamation success is dependent on cross-boundary planning and cooperation.
- Several priority species use wetlands or lakes as well as upland, lowland or riparian systems, thus reclamation requires a close integration of planning for lands, wetlands and aquatic systems.
- The predominance of habitat generalists in northern boreal forests enhances the importance of patchiness, edges, corridors and good connectivity among and within reclaimed environments.
- Diversity of landscapes, vegetation communities and micro-structure (for instance, woody debris) will provide optimal wildlife habitat for many boreal forest species.

D.2 Methods and Processes Used For Design Guidance

The recommendations provided in this guideline are based on research, observations and models specific to the oil sands region, wherever possible. The information is predominantly a compilation of the findings from four CEMA reports:

1. In 2002, existing information on life history, habitat requirements, distribution and population size of priority wildlife species in the RMWB was collated into a report entitled *A Review And Assessment Of Existing Information For Key Wildlife And Fish Species In The Regional Sustainable Development Strategy Study Area. Volume 1 - Wildlife* (Westworth Associates Ltd. 2002).
2. In 2003, a literature review was conducted on reclamation techniques suitable for boreal forest habitat and Priority 1 wildlife species described in the report entitled *Literature Review of Reclamation Techniques for Wildlife Habitats in the Boreal Forest* (AXYS Environmental 2003).
3. Also in 2003, a modeling and mapping exercise to classify ecosystems in a priority oil sands development area, according to qualitative habitat suitability indices for wildlife priority species was conducted and published in the report entitled *Regional Habitat Evaluation and Mapping for Key Wildlife Species in the Athabasca Oil Sands Region* (URSUS Ecosystem Management Ltd. 2003).
4. In 2006, traditional environmental knowledge (TEK) of wildlife for the purpose of habitat reclamation in the region was gathered from Aboriginal representatives from the communities of Anzac, Fort Chipewyan and Fort McKay and summarized in a report entitled *Report on Traditional Environmental Knowledge Input into Wildlife Habitat Reclamation Recommendations* (Garibaldi Heritage and Environmental Consulting. 2006a).

These reports, initiated by the BWSG, were focused on priority species (Priority 1, 2 and 3 Species; Ursus 2002) previously chosen by the SEWG. For this wildlife appendix, the BWSG selected fourteen of these priority species and two bird guilds to represent communities holding ecological or socio-economic importance in the oil sands region. The fourteen species and two bird guilds were selected from the SEWG list based on an evaluation of the following three scenarios[9]:

- Wildlife targets defined by the 1998 version of the Revegetation Manual;
- Wildlife Key Indicator Resources utilized in Environmental Impact Assessments as part of the project submission process under the *Environmental Protection and Enhancement Act*; and
- Wildlife targets defined by other initiatives in the RMWB such as the SEWG Wildlife and Fish Subgroup, the End Pit Lake Subgroup and the Boreal Caribou Committee.

The fourteen priority species and two bird guilds as well as the corresponding SEWG goals are listed in Table D.1. Latin and Aboriginal names for priority species are listed in Section D.5, Table D.6.

References to suitability of ecosite phases for wildlife in this document are based on model estimates, notably three site-specific derivations of habitat suitability indices[10]. This index technique is a means of predicting habitat use by wildlife, where the actual use has not been validated[11]. As such, the model results are considered an estimate of use and validation of the modeling results should be undertaken, whenever possible. The ecosite phases identified here represent habitat that was deemed highly suited to each species' life history requirements[12].

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[9] RWG Wildlife Subgroup 2002

[10] Bovar Environmental 1998; URSUS Ecosystem Management 2003; Golder Associates 2007

Sections D.3, D.4 and D.5 are based on the following assumptions:

1. The planning team applying this information will consist of a number of specialists, including Aboriginal people, engineers, soil scientists, botanists and wildlife ecologists, who will use their expertise to design elements of each landscape;
2. When planning using the target ecosite or end land use approaches (See Section 2 of the main text of the Revegetation Manual), wildlife habitat may be identified as a primary end land use objective[13];
3. When designing for habitat, planners will try to incorporate the fundamental elements required by a species or community, rather than every possible useful element; and
4. Reclaimed areas will provide different habitat values to wildlife as they proceed through succession.

Although this wildlife appendix offers guidance on which ecosites and habitat characteristics may be suitable for the priority species presented within, the guidance is not intended to imply that all wildlife habitat in the reclamation landscape should be designed to meet the needs of the priority species only. Furthermore, the guidance is not intended to imply that all of the priority species should be considered equally in reclamation efforts.

The planning for which priority species and which habitat types to target for a reclaimed landscape should be based on a systematic, ecologically based method to avoid decision-making based on operational constraints alone. Several factors that should be considered in this decision-making method are listed below:

- Conservation and management concerns;
- Likelihood of success of reclaiming certain habitats;
- Biodiversity goals;
- Similarity of target habitats to pre-disturbance habitat types;
- Integration with existing surrounding environment;
- Overall landscape design;
- Reclamation certification criteria; and
- Stakeholder interests.

Which of these factors (and other factors not listed) is more important than others involves value judgements and requires stakeholder input.

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[11] Salmo Consulting, URSUS Ecosystem Management and GAIA Consultants 2001

[12] in two instances, a quantitative rating >0.6 or 0.7 (on a 0 – 1 scale) was deemed suitable (Bovar Environmental 1998; Golder Associates 2007) and in one instance qualitative ratings of 'high' or 'very high' were identified as suitable ecosite phases (URSUS Ecosystem Management 2003)

[13] where the planning team wants to reclaim habitat for a priority species refer to Section D.5

Table D. 1 SEWG goals and indicators for wildlife, including habitat reclamation (extracted from SEWG terms of reference, November 2004)

Goal	Indicator	Rationale
Sustain viable & healthy populations of wildlife	All species	All wildlife is interconnected[14]
Protect & sustain unique, threatened, endangered & other species of concern	Canadian toad	'At risk' designation (red list in Alberta)[15]
	Woodland caribou	'Threatened' designation (blue list & COSEWIC[15].
Sustain wildlife species with an important ecological role	Lynx / snowshoe hare	Key mammal predator/prey dynamic in region
	Pileated woodpecker	Creates habitat for cavity-nesting birds & mammals
	Beaver	Engineers habitat & thereby manipulates distribution of water & soil nutrients
Sustain wildlife species that are habitat specialists	Old growth forest bird community	Require structural elements found in old forests (>100 y)
	Boreal owl	Require structural elements found in old forests (>100 y)
	River otter	Require moving water habitats (streams, rivers)
Sustain species that are important for cultural, spiritual, medicinal & ceremonial purposes	Black bear	A powerful spirit animal important to Aboriginal people for all purposes listed
Sustain wildlife populations for subsistence, commercial and/or recreational hunting, fishing & trapping	Moose	Remains a staple country food[16], cultural keystone species
	Muskrat	Foundation of traditional trap-lines
	Fisher / red-backed vole	Important fur species & its key prey base
	Ruffed grouse	Valued upland game bird
Sustain wildlife populations for recreational non-consumptive use	Mixed wood forest bird community	Aesthetic value for bird-watchers, photographers, hikers, etc.

Based on these assumptions, Section D.3 focuses on landscapes including patterning and connectivity. Section D.4 focuses on the ecosystems (forest), including hydrogeomorphology (e.g., topography, soil structure, moisture regimes), canopy characteristics, understory or wetland plant characteristics, and forest floor structure. Section D.4 is divided into subsections according to stand age and terrestrial or wetland form. Pioneer to early seral forests were distinguished from mature seral to old growth forests for two main reasons:

1. Reclamation planning, in the short- to medium-term, will be focused on the construction and maintenance of young forests, and constructed wetlands thus the divisions are intuitive from a planning perspective.

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[14] Garibaldi Heritage and Environmental Consulting 2006a,b

[15] Westworth Associates 2002

[16] Peace-Athabasca Delta Project Group 1972

2. Some of the priority species use pioneer or early seral forests for one set of habits (browsing or foraging for instance) and mature or climax forests for another (like reproduction), thus the divisions are also relevant from an ecological perspective.

Also in keeping with the above assumptions, Sections D.3 and D.4 focus on forest or wetland design elements and not the priority species themselves. Section D.5 focuses on the individual priority species and the full complement of habitats each requires for survival and reproduction. The provision of alternate focal perspectives should allow closure teams to plan and design for wildlife uses within the larger context of landform or watershed reclamation.

The guidance provided throughout this appendix relates to wildlife habitat, thus it defines forage, water and cover needs. However, it does not describe how to build the landscapes, establish the cover vegetation or store the water, because guidance on these issues is provided by other CEMA guidance documents[17]. This section is devoted to designing these essential elements with wildlife needs in mind. Guidance is provided for wildlife habitat design at the ecosite phase level, which differs from the strategy in the main body of the Revegetation Manual where planning is directed at the ecosite level. The habitat elements linked to the priority species are ecosite attributes which contribute to the stratification of an ecosite into phases. The development of ecosite phases on the reclamation landscape will require years to decades, but incorporating the habitat elements into reclamation planning process is recommended to promote the establishment of wildlife habitat capability.

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[17] a discussion of natural landform characteristics is available in MacMillan et al. 2006; wetland guidance is available in Alberta Environment 2008; end pit lake guidance is available in Westcott and Watson 2006; revegetation guidance is available elsewhere in this document; landscape design guidance is available in CEMA-RWG Landscape Design Subgroup 2005)

D.3 Designing Landscapes to Optimize Wildlife Use

Much of the wildlife inhabiting the boreal forest of northeastern Alberta has adapted to large spaces and extreme climate and natural disturbances (cold winters, large forest fires, cyclic forest insect infestations)[18]. The adaptive mechanisms these species use include generalist habits, large home ranges, seasonal migrations or other over-wintering strategies, and cyclic population fluctuations. The efficacy of these mechanisms is contingent on landscape patterning and connectivity of various habitat forms. Hence, strategic design of landscapes and watersheds is as important, if not more important than the targeted design of each forest stand in terms of end wildlife use. Many of the larger mammals and nomadic birds have home range sizes covering 50 km^2 or more. Landscape design for these species is critical and will inevitably involve some coordination of management efforts across lease boundaries.

D.3.1 Species' Requirements for Landscape Patterning & Connectivity

Landscape patterning addresses wildlife needs for:

- Interspersion of forests of different ages and vegetation communities (ecosite phases);
- Interior patch size and edges between relatively young and old stands or open and closed stands; and
- Arrangement and relative proportions of terrestrial (upland, lowland, riparian), wetland and fully aquatic environments.

Landscape patterning is a critical design element for moose, lynx, fisher, black bear, snowshoe hare, ruffed grouse, mixedwood forest birds, beaver, muskrat, and Canadian toad. A gently undulating landscape with a diversity of slopes, aspects, elevations and moisture holding capabilities, slightly more rolling than that designed for reforestation, and with a mosaic of vegetation types interspersed between lakes and wetlands is recommended for wildlife habitat[19].

Connectivity of forest stands within a landscape is important for:

- Wildlife moving between seasonal or forage and cover habitats; and
- Immigration into and dispersal across reclaimed lands.

Many species will not or cannot cross forest openings larger than a threshold width. Some, like lynx, require very specific stand ages or canopy covers for travel. The most common habitat used for seasonal movements is established riparian forest.

Table D.2 lists spatial bounds and sequencing suggestions for priority species that use more than one type of habitat in the oil sands region. In most cases, a number of species may benefit from the same landscape patterning.

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[18] Foote 2003

[19] the range of natural landforms in the region, their geological and topographical properties are described in MacMillan et al. 2006

Table D. 2 Habitat interspersion requirements of priority species[20]

	Design Element	Minimum Patch Size[21]	Species
Landscape patterning	Open young (7 - 30 y) forest within 100 m of closed older forest & an overall open:closed canopy ratio of 65:35	2 - 5 ha	moose
	Upland aspen islands within lowland peatlands adjacent to river valley bottoms	1000 ha (HR)	moose
	Shrubby young (~10 y) forest within 400 m of closed coniferous forest & many edge habitats	10 ha	snowshoe hare
	Shrubby young forest within 200 m of 2+ ha patches of mature upland coniferous forest having north-facing aspects	2000 ha (HR)	black bear[22]
		4000 ha (HR)	lynx
	Young coniferous or conifer-dominated mixedwood forest patches (200 ha, 25+ m wide) within older mixedwood forest	200 ha	fisher
	Open mixedwood forest (100 - 500 ha) with patches of old dense coniferous or mixedwood forest (15 - 20 ha)		boreal owl
		1500 - 4000 ha (HR)	fisher
	Large old growth forest blocks with minimal edges phasing into old growth blocks with many edges abutting younger stands	10 - 190 ha	old growth forest birds mixedwood forest birds pileated woodpecker
	Sequence of aspen to mixedwood to white spruce stands		boreal owl
		10 - 190 ha	old growth forest birds
	Contiguous mix of early-, mid- & late-seral upland stands with many edges	10 ha	mixedwood forest birds
		4 ha	ruffed grouse
	Mixed-age riparian stands 100+ m wide surrounding streams >0.8 km long & <5 m wide, and wetlands & lakes >1.3 km^2	2 ha	beaver
		4 ha	river otter
	Sandy upland slopes < 50 m from standing water	100 m	Canadian toad
Connecting corridors	Riparian lowland forest		beaver Canadian toad
		200 ha	fisher
		60 m wide	old growth forest birds
		500 m wide	moose
			muskrat river otter
	Rivers & streams	10 km	beaver (open) moose (frozen) muskrat (open)
		10 km	river otter (open)
	Contiguous aspen forest		ruffed grouse
	Dense coniferous forest		fisher snowshoe hare
	Mature closed mixedwood forest		black bear
	Intermediate-aged mixedwood closed forest, 420 - 640 trees/ha		lynx
Forest gaps	Openings < 25 m	200 ha	fisher
		10 - 190 ha	old growth forest birds
	Openings < 60 m	2 ha	red-backed vole[23]
	Openings < 90 m	1000 ha	lynx
	Openings <100 m wide, <400 m long, & <30 % of total area	2 - 5 ha	moose

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[20] design reference is AXYS Environmental Consulting 2003 or Westworth Associates 2002 unless otherwise footnoted

[21] in most cases, refers to the patch size of the foraging / cover / breeding habitat described; (HR) refers to an average home range size & may be used as a broad guideline where more specific patch sizes are not known; a range is given where patch size is species-specific (for bird guilds) or where it varies with habitat quality

[22] Bovar Environmental 1998

[23] Gillis and Nams 1998

D.3.2 Cross-boundary Planning & Evaluation of Disturbance

The large home ranges or migratory/nomadic lifestyles of several of the priority species preclude their isolated, lease-level management. This is particularly true for moose, woodland caribou, black bear, lynx, pileated woodpecker and boreal owl. In addition, there are species that require the maintenance of undisturbed forest habitat for all or part of their life. Secluded breeding or denning habitat is essential for moose, woodland caribou, black bear, lynx, fisher, and some old growth and mixedwood forest birds.

Efficient planning and habitat design for these species will require varying levels of cross-boundary planning and monitoring. Cross-boundary planning will need to consider that wildlife does not recognize property boundaries. In addition, planning will need to consider that wildlife does recognize barriers, such as large clearings, roads, nearby disturbance, a lack of surface water systems or building clusters. Some tools that may be useful in planning for these species are:

- Strategic set-asides of habitat refugia, based on local knowledge of wildlife habits, pre-disturbance assessments and particularly that held by Elders[24];
- Connecting corridors across developed and early reclaimed landscapes to encourage immigration of wildlife from surrounding, intact boreal forest (corridors should be riparian forest along main rivers/tributary streams or upland forest spanning ridges)[25];
- Coordinated alignment of watercourses across lease boundaries;
- Development of a common digital elevation model among neighbouring operators to ensure that water will flow across leases and into the surrounding environment;
- Coordinated retention of old growth forest and bog/fen patches to service the needs of breeding and foraging wildlife[25];
- Shared use and minimal development of private roads on leases and for exploration;
- Inter-mine coordination of reclamation materials, such as downed woody debris, snags, peat, clay-loam or sandy soils or boulders[26]; and
- Spatial sequencing of seral stages of upland, lowland and riparian reclaimed forests[25].

These strategies address long-term and far-ranging issues, and require temporal continuity. The transition from mining to forestry on some lands may benefit from cross-boundary plans and agreements.

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[24] refugia may also serve as sources of seed for native vegetation establishment and soil microbial communities

[25] AXYS Environmental Consulting 2003

[26] a recommendation put forth by Alberta Government during Imperial Oil's application for oil sands mining at Kearl Lake (C Farn-Baker, Alberta Energy & Utilities Board, pers. comm.)

D.4 Ecosite Phase Design Elements that Favour Wildlife Use

Ecosite phases are defined by the existing microclimate, moisture and nutrient regimes, which dictate the community composition of the vegetation (Table D.3). Forest stand diversity and age, and the related structural and functional complexity (including the presence of deadfall and debris) strongly influence the suitability of an ecosystem for wildlife. This section focuses on the key determinants of wildlife use in forested landscapes, namely hydrogeomorphology, forest canopy, shrub understory and forest floor properties.

D.4.1 Pioneer and Early Seral Forests

These forests will likely be the first upland, lowland and riparian habitat suitable for priority species on reclaimed landscapes (outside of refugia). They will contain pioneer and early seral tree and shrub species[27], and be younger than 60 – 80 years[28]. These environments are of critical importance as foraging habitats for wildlife. The priority species that will use them frequently to browse are moose, snowshoe hare, red-backed vole, black bear, ruffed grouse and beaver (the latter in riparian stands only). The priority species that will use them to hunt for prey are fisher and lynx. In addition, young mixedwood forests will provide habitat for a nesting bird community, and some sites may be appropriate for hibernacula of Canadian toad.

Design elements pertaining to the shrub understory will likely have the greatest influence on end use by wildlife. Moose, snowshoe hare and beaver exhibit strong palatability preferences for certain species of young, woody browse[29]. Similarly, black bear and grouse prefer stands with a proliferation of berry-producing species. Palatability of browse may be influenced by the mineral content of reclaimed soils, salinity and sodicity in particular. Digestibility of browse during seasonal changes from woody to succulent vegetation may also be significantly influenced by mineral content of lick soils[30]. Further research in these latter areas is needed (see section D.7 for recommendations on research initiatives).

Table D.4 lists the key habitat elements in young and developing stands that are required for these species to forage, breed or over-winter. Only snowshoe hare, ruffed grouse and perhaps some mixedwood birds may be able to meet all of their habitat needs in these young forests. Riparian and lowland ecosite phases are included where appropriate.

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[27] see Appendix F in Geographic Dynamics Corp 2002

[28] URSUS Ecosystem Management 2003; < 80 y for black spruce mixed-wood, black spruce or white spruce stands & < 60 y for all others.

[29] see Section D.5

[30] Ayotte et al. 2006

Table D. 3 Ecosite phases useful for wildlife habitat and corresponding dominant canopy and shrub understory species in mature communities

Ecosite Phase	Dominant Tree Species	Dominant Shrub Species[31]
a1 lichen, jack pine	Jack pine	Blueberry, common bearberry, bog cranberry, green alder, Labrador tea, twin-flower, sand heather, rose, dwarf bilberry, common juniper
b1 blueberry, jack pine - aspen	Jack pine Aspen White spruce	Bog cranberry, blueberry, green alder, Labrador tea, common bearberry, twin-flower, rose, Canada buffaloberry, Saskatoon, pin cherry
b2 blueberry, aspen	Aspen White birch White spruce	Common bearberry, blueberry, bog cranberry, Labrador tea, twin-flower, green alder, rose, Canada buffaloberry, Saskatoon, common snowberry
b3 blueberry, aspen - white spruce	Aspen White spruce White birch	Blueberry, common bearberry, bog cranberry, rose, twin-flower, Labrador tea, green alder, Saskatoon, Canada buffaloberry, common juniper, twining honeysuckle
b4 blueberry, white spruce - jack pine	White spruce Jack pine	Common bearberry, bog cranberry, blueberry, green alder, Canada buffaloberry, Labrador tea, shrubby cinquefoil, Saskatoon, twin-flower, rose
c1 Labrador tea (mesic), jack pine - black spruce	Jack pine Black spruce	Labrador tea, bog cranberry, blueberry, green alder, twin-flower, rose, dwarf bilberry
d1 low-bush cranberry, aspen	Aspen White spruce Balsam poplar	Rose, low-bush cranberry, green alder, twin-flower, beaked hazelnut, Saskatoon, beaked willow, raspberry, Canada buffaloberry, bracted honeysuckle
d2 low-bush cranberry, aspen	Aspen White spruce Balsam poplar	Low-bush cranberry, rose, twin-flower, green alder, bracted honeysuckle, Canada buffaloberry, beaked hazelnut, Saskatoon, beaked willow, dogwood, bog cranberry
d3 low-bush cranberry, aspen	White spruce Aspen Balsam poplar	Twin-flower, low-bush cranberry, rose, green alder, Canada buffaloberry, bog cranberry, bracted honeysuckle, raspberry, bristly black & skunk currants, beaked willow, blueberry, gooseberry
e1 dogwood, balsam - aspen	Aspen Balsam poplar White spruce	Rose, low-bush cranberry, dogwood, twin-flower, beaked willow, bracted honeysuckle, river alder, raspberry, green alder, common snowberry
e2 dogwood, balsam - white spruce	White spruce Aspen Balsam poplar	Dogwood, low-bush cranberry, bracted honeysuckle, rose, twin-flower, green alder, beaked willow, northern gooseberry, bristly black currant, pin cherry
e3 dogwood, white spruce	White spruce Aspen Balsam poplar	Low-bush cranberry, bracted honeysuckle, rose, green alder, twin-flower, dogwood, raspberry, red currant, northern gooseberry, skunk currant
f1 horsetail, balsam - aspen	Balsam poplar Aspen Birch	Raspberry, low-bush cranberry, rose, dogwood, beaked willow, river alder, twin-flower, bracted honeysuckle, northern gooseberry, common snowberry
f2 horsetail, balsam - white spruce	White spruce Aspen Balsam poplar	Low-bush cranberry, dogwood, rose, twin-flower, river alder, raspberry, bracted honeysuckle, beaked willow, bristly black currant, skunk currant, northern gooseberry, red currant
f3 horsetail, white spruce	White spruce	Twin-flower, rose, low-bush cranberry, beaked willow, dogwood, bracted honeysuckle, northern gooseberry, bristly black currant, red currant, skunk currant, river alder, alder-leaved buckthorn, raspberry, velvet-leaved willow

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[31] top 10 species in order of ranked dominance (highest prominence scores and mean percent cover) from Appendix H of Geographic Dynamics Corp 2002; there may be more than ten species listed if there were ties in dominance ranks

Ecosite Phase	Dominant Tree Species	Dominant Shrub Species[32]
g1 Labrador tea (subhygric), black spruce – jack pine	Black spruce Jack pine	Labrador tea, bog cranberry, blueberry, rose, green alder, myrtle-leaved willow, twin-flower, flat-leaved willow, beaked willow, alpine bearberry
h1 Labrador tea – horsetail, white spruce – black spruce	White spruce Black spruce	Labrador tea, bog cranberry, rose, green alder, twin-flower, beaked willow, low-bush cranberry, bracted honeysuckle, velvet-leaved willow, myrtle-leaved willow, bristly black currant
i1 treed bog	Black spruce	Labrador tea, bog cranberry, small bog cranberry, leatherleaf, bog rosemary, northern bog laurel, crowberry
i2 shrubby bog	-	Labrador tea, bog cranberry, northern bog laurel, leatherleaf, small bog cranberry
j1 treed poor fen	Black spruce Larch / tamarack	Labrador tea, bog cranberry, myrtle-leaved willow, small bog cranberry, crowberry, dwarf birch, bog willow, flat-leaved willow, bog rosemary, beaked willow, hoary willow, grey-leaved willow, balsam willow
j2 shrubby poor fen	-	Labrador tea, dwarf birch, bog cranberry, bog rosemary, leatherleaf, bog willow, myrtle-leaved willow, small bog cranberry
k1 treed rich fen	Larch / tamarack	Dwarf birch, bog rosemary, Labrador tea, northern bog laurel, bog willow, water birch, small bog cranberry, hoary willow, bog cranberry, mountain willow
k2 shrubby rich fen	-	Flat-leaved willow, river alder, dwarf birch, bog willow, beaked willow, skunk currant, velvet-leaved willow, dogwood, red currant, myrtle-leaved willow, bristly black currant, rose
k3 gramminoid rich fen	-	Dwarf birch, hoary willow, bog willow
l1 marsh	-	Dwarf birch

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[32] top 10 species in order of ranked dominance (highest prominence scores and mean percent cover) from Appendix H of Geographic Dynamics Corp 2002; there may be more than ten species listed if there were ties in dominance ranks

Table D. 4 Design elements in pioneer and early seral forests that are beneficial to priority species of wildlife[33].

	Design Element	Potential Ecosite Phases[34]	Species That Benefit (& Activity)[35]
Hydrogeomorphology	Slopes <15° & not rocky Clay, sodic overburden (sodium-rich, potassium-poor) soil patches in uplands and lowlands	A1 b1 b2 b3 d1 d2 e1 e2 e3 f1 f2	moose (movement)
	Riparian slopes <10° for 60 m (from water) Banks of waterways <1 m high & composed of fine-grained soil	e1 f1 I1	beaver (foraging)
	South-facing slopes ~40° & sandy non-saline soil that extends below frost line but remains above water table	a1 b1 b2 b3 b4	Canadian toad (over-wintering)
	Coarse-grained (sand or gravel) soil patches in uplands	a1, b1 b2 b3 b4	ruffed grouse (foraging)
	Moist (mesic to hygric) soils	d1 d2 e1 e2 e3 f1 f2	red-backed vole
	No hydrogeomorphology elements identified for use of pioneer / early seral stands	-	black bear (foraging) fisher lynx (foraging) mixedwood forest birds snowshoe hare
Forest Canopy	Upland stands dominated by aspen, jack pine, balsam poplar & white birch	a1 b1 b2 b3 d1 d2	Canadian toad lynx mixedwood forest birds moose red-backed vole ruffed grouse
	Riparian stands dominated by aspen, willow, balsam poplar & alder < 100 m from waterway	e1 f1 I1 k3	beaver (foraging) Canadian toad (foraging)
	Mixed wood stands dominated by conifers (>50 % species composition)	b1 d3 e2 f2	fisher lynx mixedwood forest birds snowshoe hare
	Upland aspen stands (>20 % species composition) of mixed ages	b2 b3 d1 d2	mixedwood forest birds moose ruffed grouse
	Dense black spruce thickets (coverts) on ridges	h1 j1 k1 i1	fisher (foraging) moose snowshoe hare (cover)
	Sparse mixedwood over-story (<60 % closure)	b1 b3 d2 d3 e2 f2	black bear (foraging) mixedwood forest birds moose (foraging)
	Mixed wood stand density of 420-640 trees per ha	b1 d2 e3 f2	lynx (movement)

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[33] See Section D.5 for detailed requirements of each species and literature sources for guidance recommendations

[34] Potential ecosite phases are derived from the habitat suitability indices (HSIs) produced by Bovar Environmental 1998, URSUS Ecosystem Management 2003 and Golder Associates 2007; for understory design, suitable ecosite phases were further identified using the ranked list of ten dominant shrub species for each ecosite phase presented in Appendix H of Geographic Dynamics Corp 2002; ecosites 'a' through 'd' were identified as upland, 'e' and 'f' as riparian and 'g' and 'h' as lowland habitats (URSUS Ecosystem Management 2003)

[35] where an activity is not specified, the design element meets the species' general living requirements

	Design Element	Potential Ecosite Phases[36]	Species That Benefit (& Activity)[37]
Understory	≥30 % composition of alder, high-bush & low-bush cranberry, pin cherry, red willow / dogwood, Saskatoon, willows	d1 d2 e2 f1 f2	moose (browse)
	≥17 % composition of alder, blueberry, buffalo berry, bunchberry, horsetail, low-bush cranberry, raspberry, rose, Saskatoon, willows & total ground cover ≥65-70 %	b1 b2 b3 d1 d2 e2 f1 f2	ruffed grouse (browse) snowshoe hare (browse)
	Large berry patches: blueberries, cranberries, Saskatoon, buffalo-berry, rose, raspberry, bearberry / stoneberry, chicken-berry / bunchberry, wild sarsaparilla / rabbit root, red willow / dogwood	a1 b1 b2 b3 d1 d3 e1 e3 f1 f2	black bear (browse)
	30-70 % cover of dwarf birch, willows, Labrador tea, bearberry	g1 h1 j1 k1 i1	fisher (cover) lynx (cover)
	Dense red willow / dogwood, alder, raspberry	d1, d2, d3 e1, e2, e3	red-backed vole (cover)
	Dense shrub willows in riparian thickets	i1	snowshoe hare (cover)
	Dense tall woody shrubs (canopy >1.5 m)	e2 d3 f1 f3	Mixed wood forest birds
	Widely spaced fast-growing woody shrubs	d1 e1 f1	beaver (foraging)
	Sparse non-invasive grasses or forbs with shallow, diffuse root systems (wormwood, rose)	a1 b1	Canadian toad (over-wintering)
	Grassed clearings < 0.5 ha within upland stands	b1 b2 b3 d1 d2	black bear (foraging) moose (rut) ruffed grouse (brood-rearing)
Forest Floor	Dense rotting woody debris, moss / duff & brush piles	b1 d1 e1 k1 i1	red-backed vole
	Ectomycorrhizal fungi on rotting woody debris & terrestrial lichens	b1 d1 e1 f1 (but all ecosite phases)	red-backed vole (foraging)
	10-15 % cover of downed woody debris (brush piles, tree roots, logs)	a1 b1 d3 e2 f2 g1 h1 (all ecosite phases)	mixedwood forest birds (nesting) snowshoe hare (cover)
	Multiple drumming logs (poplar, conifers) on floor per 2.5 ha male territory	b1 b2 b3 d1 d2 (all upland ecosite phases)	ruffed grouse (mating)
	Coarse woody debris > 20 cm diameter, > 30 cover pieces/ha & snags	a1 b1 g1 h1 (all upland ecosite phases)	fisher (nesting)
	No forest floor elements identified for use of pioneer / early seral stands	-	beaver black bear Canadian toad lynx moose

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[36] Potential ecosite phases are derived from the habitat suitability indices (HSIs) produced by Bovar Environmental 1998, URSUS Ecosystem Management 2003 and Golder Associates 2007; for understory design, suitable ecosite phases were further identified using the ranked list of ten dominant shrub species for each ecosite phase presented in Appendix H of Geographic Dynamics Corp 2002; ecosites 'a' through 'd' were identified as upland, 'e' and 'f' as riparian and 'g' and 'h' as lowland habitats (URSUS Ecosystem Management 2003)

[37] where an activity is not specified, the design element meets the species' general living requirements

D.4.2 Mature Seral and Climax (Old Growth) Forests

Forests planted today on reclaimed landscapes will not reach mature seral canopy compositions for 60 - 160 years[38]. Nonetheless, there are several priority species, particularly the predators and cavity-nesting birds, which require elements of mature and climax forests to reproduce successfully. These elements typically relate to decay structures (dead or dying standing trees, fallen & rotting logs) and complex forest floor structure (debris, moist micro-environments, cover diversity), which are difficult to adequately replicate in younger, engineered stands. Engineering this complexity may be feasible for some of the smaller species (red-backed vole for instance), but will likely not succeed for the larger mammals and avian cavity-nesters. Therefore, guidance in this section will relate to long-term management, with the assumption that other avenues of habitat provision, such as the conservation of strategically-placed refugia, will also be explored to satisfy the short- and long-term needs of wildlife associated with these forest age classes. For example, mining operations may be able to plan for the inclusion of refugia along edges or riparian buffer zones.

Late seral and climax forests are used as breeding and cover habitat for moose, lynx, fisher, old growth forest birds, pileated woodpecker, and boreal owl. Black bear require mature forests for den habitat, which is used when over-wintering and for cub-rearing. Red-backed vole often meets all of its habitat needs within mature boreal forests. Pileated woodpeckers excavate large tree cavities that are secondarily used by a number of other birds and mammals, including boreal owl and fisher. The presence of large decaying trees is the key determinant for habitat use by these large-bodied cavity nesters. Soil composition, moisture content and canopy tree density may be the key variables limiting habitat use by black bear, moose and red-backed vole. The list of potential ecosite phases that may fulfill these habitat needs is extensive and often limited only by species' preferences for upland, riparian or lowland settings. Table D.5 lists the habitat elements in mature and old growth stands that are required for priority species to breed or over-winter.

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[38] URSUS Ecosystem Management 2003; 61 - 120 y for deciduous & deciduous mixed-wood, 61 - 140 y for coniferous mixed-wood & jack pine, 81 - 160 y for black or white spruce stands

Table D. 5 Design elements that favour use of mature seral and climax forests by priority species of wildlife[39].

	Design Element	Potential Ecosite Phases[40]	Species That Benefit (& Activity)[41]
Hydrogeomorphology	Undisturbed lowland riparian stands & islands > 1 km from roads	e1 e2 e3 f1 f2 f3 k3 l1	moose (calving)
	Well-drained, coarse-grained upland soils >1.5 m thick with north-facing aspect	a1 b1 b2 b3	black bear (denning)
	Moist soils	d-h ecosites	red-backed vole
	Clay, sodic overburden (sodium-rich, potassium-poor) soil patches in lowlands[42]	as for moose (calving)	moose (foraging)
	North-facing aspect & rocky outcroppings	b1 b2 b3 b4 c1 d1 d2 d3 e1 e2 e3 f3	lynx (denning) fisher (denning)
	No hydrogeomorphology elements identified for use of mature seral/old growth stands	-	boreal owl old growth forest birds pileated woodpecker
Forest Canopy	Mixed wood dominated by balsam poplar, white spruce, white spruce - aspen or jack pine, > 40-50 % conifers & patches of black spruce	a1b1 b3 b4 b2 b4 d2 d3 e2 f2 h1 g1	black bear boreal owl (>200 trees per ha) fisher lynx old growth forest birds red-backed vole
	Sparse (25 - 50 m spacing) white spruce stands within mixedwood, mixed-age forest	b4 d3 e2 e3 f2 f3	old growth forest birds
	Aspen stands within mixedwood dominated by aspen, balsam poplar or white spruce	b1 b2 b3 d1 d2 d3 e2 f2	fisher (nesting) pileated woodpecker
	Nest boxes 10 m above ground	b4 d3 e2 e3 f2 f3 g1 h1	boreal owl (nesting)

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[39] see Section D.5 or AXYS Environmental Consulting 2002 unless other citation is given

[40] Potential ecosite phases are derived from the habitat suitability indices (HSIs) produced by Bovar Environmental 1998, URSUS Ecosystem Management 2003 and Golder Associates 2007; for understory design, suitable ecosite phases were further identified using the ranked list of ten dominant shrub species for each ecosite phase presented in Appendix H of Geographic Dynamics Corp 2002; ecosites 'a' through 'd' were identified as upland habitat and 'e' through 'h' as riparian (URSUS Ecosystem Management 2003)

[41] where an activity is not specified, the design element meets the species' general living requirements

[42] Ayotte et al. 2006

	Design Element	Potential Ecosite Phases[43]	Species That Benefit (& Activity)[44]
Understory	Sparse red willow/dogwood, willows	e1 e2 f1 f2 f3 k3 l1	boreal owl (foraging) moose (browse, calving)
	Sparse low-growing shrubs	a1b2 b3	pileated woodpecker (nesting)
	30-70% cover of dwarf birch, willows, Labrador tea, bearberry, cranberries	g1 h1	lynx (cover)
	Dense red willow/dogwood, currants, alder, raspberry	b1 b3 b4 d1	red-backed vole
	Dense shrubs along stand edges	b1 b4 d2 d3 e2 e3 f2 f3	old growth forest birds
	No understory elements identified for use of mature seral/old growth stands	-	black bear fisher
Forest Floor	Dense rotting woody debris, duff, brush piles	b1 b3 b4 d1 d2 d3 e1 e2 e3 f2 f3 g1 h1 (all upland ecosite phases)	boreal owl (foraging) fisher (nesting) old growth forest birds red-backed vole
	Dense clusters of large, downed trees, angled or suspended up to 1.5 m above ground	a1 b1 b2 b3 d1 d2 d3 e1 e2 e3 f1 f2 f3 g1 h1	black bear (cover) fisher (nesting) lynx (denning, >1 log/1.6 m) pileated woodpecker (foraging, >7 logs/ha)
	No forest floor elements identified for use of mature seral/old growth stands		moose
Conservation of Refugia	Remote mature riparian forest > 100 m^2 & 500 m wide	e1 e2 e3 f1 f2 f3	moose (calving, travel)
	Remote mature upland mixedwood forest	a1 b1 b2 b3 d1 d2 d3	black bear (denning)
	Old growth mixedwood or coniferous patches within large mixed-age stands	b1 b3 b4 d2 d3 e2 e3 f2 f3 g1 h1	fisher lynx (2+ ha patches) old growth forest birds (15 - 160 ha patches) red-backed vole (2+ ha patches)
	Aspen-dominated old growth forest ≥ 1700 ha	b1 b2 b3 d1 d2 e2 f2	pileated woodpecker
	Old growth mixedwood forest ≥ 1200 ha	d3 e2 f2 h1	boreal owl (nesting)
	Old white spruce trees or stands	b4 d3 e2 e3 f2 f3	old growth forest birds
	Coniferous snags and/or standing decaying large (>10 cm dbh) deciduous trees	b1 b2 b3 b4 d1 d2 d3 e2 e3 f2 f3	boreal owl fisher pileated woodpecker

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[43] Potential ecosite phases are derived from the habitat suitability indices (HSIs) produced by Bovar Environmental 1998, URSUS Ecosystem Management 2003 and Golder Associates 2007; for understory design, suitable ecosite phases were further identified using the ranked list of ten dominant shrub species for each ecosite phase presented in Appendix H of Geographic Dynamics Corp 2002; ecosites 'a' through 'd' were identified as upland habitat and 'e' through 'h' as riparian (URSUS Ecosystem Management 2003)

[44] where an activity is not specified, the design element meets the species' general living requirements

D.4.3 Treed and Open Wetlands

The dominant wetland classes in the boreal forest of northeastern Alberta are treed or shrubby forms of bogs and fens. The other, less common treed class present is swamps. Wetlands occur where the water table is at, near, or above the land surface or where the land is saturated long enough to promote hydric soils, hydrophytic vegetation and a wet-adapted ecological dynamic[45]. Wetlands are shallower than lakes, with depths less than 2 m at mid-summer. They are not riparian margins, which are transitional between wetlands and uplands. The revised wetland guideline provides an extensive discussion of the state of knowledge on wetland reclamation, including recommendations on wildlife habitat design. The creation of treed wetlands on reclaimed oil sands landscapes is not yet tested, but field scale trials of fen reclamation are underway[45].

This section will outline recommendations to reclaim wildlife habitat, with the acknowledgement that such reclamation will only be feasible once research identifies how the hydrology for these systems can be engineered. The priority species that use wetlands to fulfill most of their needs are woodland caribou, muskrat, and river otter. In addition, moose use wetlands for foraging and calving, beaver use them for housing and summer foraging, and Canadian toad use them for breeding. The ungulates use predominantly fens and bogs, whereas the fur-bearers and amphibians use standing water in marshes and ponds, in conjunction with fully aquatic habitats like streams and lakes[45]. Table D.6 lists the key habitat elements in treed and open wetlands that are required for these species to survive and or reproduce. Reclamation of some wetland classes, such as bogs, may not be possible for many years; therefore, the preservation of specific wetland forms in refugia may be necessary in the region. These requirements for long-term management are also identified in Table D.6.

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[45] Alberta Environment 2008

Table D. 6 Design elements that favour use of treed and open wetlands by priority species of wildlife[46].

	Design Element	Potential Ecosite Phases[47]	Species That Benefit (& Activity)[48]
Hydrogeomorphology	Access from low banks (<1 m) and wide, low gradients (0.5 %) in emergent zone	j1 j2 k1 k2 l1	Canadian toad (breeding) moose (foraging) muskrat (foraging)
	Slopes <15°	j1 j2 k1 k2 k3	moose (travel) woodland caribou (travel)
	Water table <20 cm below ground surface & non-saline, non-sodic soils	i1 i2 j1 j2 k1 k3	woodland caribou
	Semi-stable water depths ~1.2 m with periodic seasonal flooding	l1	muskrat
	Stable water depths 1.8 - 2.1 m	l1 shallow ponds	beaver river otter
	Firm, fine-grained substrate along shorelines	l1	beaver (foraging) muskrat (housing)
	Standing or slow-moving surface water (June - Aug)	j1 j2 k1 k3 l1 l2 l3	Canadian toad (breeding)
Forest Canopy	Dense (>50 % cover) black spruce - willow - tamarack	i1 j1 k1	moose (calving)
	Treed bog & fen stands dominated by black spruce, willows, red willow/dogwood, bog & white birches, balsam poplar	i1 j1 k1	woodland caribou
	Moderate bank & shoreline cover (>25 %) of willow, poplar, birch, black spruce, red willow/dogwood, alder	k3 l1	river otter (cover)
Wetland Plants	No tree canopy elements identified for use of wetlands	-	beaver Canadian toad muskrat
	Dense cover in submergent zone of pineapple/yellow pond lily, pondweeds & water milfoils	l1	beaver (summer foraging) moose (foraging)
	Dense (40 to 75 %) cover in emergent zone of cattail, rat root, bulrush, reed-grass & sedges	l1	Canadian toad muskrat river otter
	Shrubby fens and bogs with sedges (>8 %), forbs (>11 %) and shrubs (>18 %)	i2 j2	woodland caribou
Conservation of Refugia	Patches (2 - 5 ha) of open bogs & black spruce - willow fens with internal upland islands	i2 j1 k1	moose
	Large blocks (>34 km²) of treed bogs & fens (>30 % bog) within remote riparian stands	i1 j1 k1	woodland caribou
	Raised bog islands with discontinuous patches of permafrost & feeding craters with terrestrial lichens	i1 i2	woodland caribou

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[46] See Section D 5 or Alberta Environment 2008 unless other citation is given

[47] Potential ecosite phases are derived from the habitat suitability indices (HSIs) produced by Bovar Environmental 1998, URSUS Ecosystem Management 2003 and Golder Associates 2007; shallow open water ponds are a class of wetland according to the National Wetland Classification System (1997) applied to the revised wetlands reclamation guideline (Alberta Environment 2008)

[48] where an activity is not specified, the design element meets the species' general living requirements

D.5 Habitat Requirements for Indicator Species and Communities in Reclaimed Landscapes

The habitat descriptions in the following text are ordered first according to taxonomic class (mammals, birds, amphibians) then second by functional niche groupings (herbivores, omnivores, carnivores). Within the group of mammals, large and small herbivores (ungulates, rodents and hares) are described before large omnivores (black bears) and carnivores. Within the group of birds, community assemblages are described first followed by species accounts roughly grouped as herbivores, insectivores and carnivores.

These habitat accounts and tables (D.8 through D.23) are largely based on the literature review conducted by Westworth Associates for priority species in the RMWB[49]. Other regional reviews of western and traditional knowledge[50] are referred to with respect to specific guidance points where applicable. The ecosite phases providing highly suitable habitat for each species were estimated using the associated HSI values from mapping exercises on regional and mine-specific landscape plots[51]. As discussed in Section D.2, these estimations must be treated with caution, given issues with quantity and quality of regional empirical vegetation and wildlife population data[52].

Priority species are described throughout using both Aboriginal (where known) and common names; the corresponding Latin names are provided in Table D.7. Some useful conversion factors are listed below; metric measures are used throughout the habitat tables. The dominant canopy and shrub understory species for each ecosite phase are listed in Table D.3.

Conversion factors for measures frequently used in the following text.

Area	**Length, width or depth**
1 km^2 = 100 ha	1 cm = 0.39 in
1 ha = 2.47 acres	1 m = 3.28 ft
1 km^2 = 0.386 mi^2	1 km = 0.62 mi

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[49] Westworth Associates 2002

[50] AXYS Environmental Consulting 2003; Garibaldi Heritage and Environmental Consulting 2006a; Alberta Environment 2008

[51] Bovar Environmental 1998; URSUS Ecosystem Management 2003, 2006; Golder Associates 2007

[52] See section 5.7

Table D. 7 Aboriginal/local, common and Latin names for species referred to in this section.

Group	Latin	Common	Aboriginal/local[53]
Trees	*Alnus tenuifolia*	river or thinleaf alder	
	Betula papyrifera	white or paper birch	
	Larix laricina	larch	tamarack
	Picea glauca	white spruce	
	Picea mariana	black spruce	
	Pinus banksiana	jack pine	
	Populus balsamifera	balsam poplar	black poplar
	Populus tremuloides	aspen (trembling)	
Shrubs	*Alnus crispa*	green alder	
	Amelanchier alnifolia	Saskatoon	
	Andromeda polifolia	bog rosemary	
	Arctostaphylos uva-ursi	bearberry (common)	kinnikinik/stone berry/chicken berry
	Betula occidentalis	water birch	
	Betula pumila/glandulosa	bog, red or dwarf birch	
	Chamaedaphne calyculata	leatherleaf	
	Cornus stolonifera	red osier dogwood	kinnikinik/red willow
	Corylus cornuta	beaked hazelnut	
	Empetrum nigrum	crowberry	otterberry
	Hudsonia tomentosa	sand heather	
	Juniperus communis	juniper (common)	
	Kalmia polifolia	bog laurel (northern)	
	Ledum groenlandicum	Labrador tea	muskeg tea
	Linnaea borealis	twin-flower	
	Lonicera spp.	honeysuckle	
	Oxycoccus microcarpus	small bog cranberry	
	Potentilla fruticosa	shrubby cinquefoil	
	Prunus pensylvanica	pin cherry	
	Rhamnus alnifolia	alder-leaved buckthorn	
	Ribes glandulosum	currant (skunk)	
	Ribes lacustre	currant (bristly black)	
	Ribes oxyacanthoides	gooseberry (northern)	
	Ribes triste	currant (red)	
	Rosa acicularis / woodsii	rose	itchy berry
	Rubus idaeus	raspberry	
	Salix bebbiana	willow (beaked)	
	Salix candida	willow (hoary)	
	Salix glauca	willow (grey-leaved)	
	Salix maccalliana	willow (velvet-leaved)	
	Salix myrtillifolia	willow (myrtle-leaved)	
	Salix pedicellaris	willow (bog)	
	Sclix planifolia	willow (flat-leaved)	
	Salix pseudomonticola	willow (mountain)	
	Salix pyrifolia	willow (balsam)	
	Sheperdia canadensis	Canada buffaloberry	
	Symphoricarpos albus	snowberry (common)	buckbrush
	Vaccinium caespitosum	dwarf bilberry	blueberry
	Vaccinium myrtilloides	blueberry	
	Vaccinium vitis-idaea	bog cranberry	
	Viburnum edule	low-bush cranberry	mooseberry
	Viburnum opulus / trilobum	high-bush cranberry	

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[53] Garibaldi Heritage and Environmental Consulting 2006a; Appendix F in Alberta Environment 2008

Group	Latin	Common	Aboriginal/local
Grasses, forbs, sedges & rushes	*Acorus calamus*	sweet flag	rat root
	Aralia nudicaulis	wild sarsaparilla	rabbit root
	Artemisia spp.	wormwood	
	Calamagrostis canadensis	joint grass (blue)	goose grass
	Carex spp.	sedges	
	Cornus canadensis	bunchberry	pin berry/chicken berry/moustache berry
	Epilobium angustifolium	fireweed	
	Equisetum spp.	horsetail	
	Lathyrus spp.	peavine / vetch pea	
	Myriophyllum exalbescens	water milfoil	
	Nuphar variegatum	yellow pond lily	beaver pineapple
	Phragmites spp.	reed grass	
	Potamogeton spp.	pondweeds	
	Sarracenia purpurea	pitcher plant	frog pants/ayekitas
	Scirpus spp.	bulrush	
	Sparganium eurycarpum	burreed	
	Typha latifolia	cattail (common)	
Lichens	*Cladina* spp.	terrestrial lichens	caribou moss
	Usnea & Evernia spp.	arboreal lichens	tree moss
Fishes	*Catostomus commersoni*	white sucker	
	Coregonus clupeaformis	lake whitefish	
	Cuiaea inconstans	brook stickleback	
	Esox lucius	northern pike	jack pike
	Thymallus arcticus	Arctic grayling	
Amphibians	*Bufo hemiophrys*	Canadian toad	
Birds	*Aegolius funereus*	boreal owl	
	Bonasa umbellus	ruffed grouse	drummer
	Certhia americana	brown creeper	
	Cyanocitta cristata	blue jay	
	D. virens	black-throated green warbler	
	Dendragapus canadensis	spruce grouse	spruce hen
	Dendroica castanea	bay-breasted warbler	
	Dendroica magnolia	magnolia warbler	
	Dendroica tigrina	Cape May warbler	
	Dryocopus pileatus	pileated woodpecker	
	Lagopus lagopus	willow ptarmigan	ptarmigan
	Loxia leucoptera	white-winged crossbill	
	Parus atricapillus	black-capped chickadee	
	Perdix perdix	gray partridge	gray chicken
	Perisoreus canadensis	gray jay	whiskey jack
	Pheucticus ludovicianus	rose-breasted grosbeak	
	Piranga ludoviciana	western tanager	
	Regulus calendula	ruby-crowned kinglet	
	Regulus satrapa	golden-crowned kinglet	
	Sitta canadensis	red-breasted nuthatch	
	Sphyrapicus varius	yellow-bellied sapsucker	
	Troglodytes troglodytes	winter wren	
	Tympanuchus phasianellus	sharp-tailed grouse	prairie chicken
	Vireo solitarius	blue-headed or solitary vireo	
	Wilsonia canadensis	Canada warbler	

Group	Latin	Common	Aboriginal/local
Mammals	*Alces alces*	moose	
	Canis latrans	coyote	
	Canis lupus	wolf	
	Castor canadensis	beaver	
	Clethrionomys gapperi	red-backed vole	
	Erethizon dorsatum	porcupine	
	Glaucomys sabrinus	flying squirrel (northern)	
	Lepus americanus	snowshoe hare	jackrabbit
	Lutra canadensis	river otter	
	Lynx canadensis	lynx	
	Martes pennanti	fisher	
	Mustela vison	mink	
	Ondatra zibethicus	muskrat	water rat
	Peromyscus maniculatus	deer mouse	
	Phenacomys intermedius	mountain vole (heather)	
	Rangifer tarandus	woodland caribou	
	Synaptomys borealis	bog lemming (northern)	
	Tamiasciurus hudsonicus	red squirrel	
	Ursus americanus	black bear	
	Vulpes fulva	red fox	

D.5.1 Moose

Moose is one of the largest herbivores in the oil sands region (along with caribou). It is a cultural keystone species for Fort McKay Aboriginal people (and may be for others), in that it continues to be a staple country food[54] and has significant cultural value for them[55]. There is a vast knowledge among Elders of the habitat and habits of moose in the oil sands region[55]. This traditional knowledge may be integral in understanding how to optimize reclamation designs for the species. Moose are habitat generalists but their broad habitat preferences are complex[56], may be location-specific and thus difficult to anticipate without the assistance of local traditional knowledge.

The habitat requirements of moose are broadly driven by the often conflicting needs for high quality browse and protection from severe weather and/or predators. Moose prefer to use young deciduous or mixedwood forests with palatable young woody growth, accessible leaves and an abundance of berry-producing shrubs for browse. However, they require the protection of denser coniferous stands or water nearby for shelter and escape[57]. Thus, a mix of forest patches and aquatic environments with many edge habitats produces the diversity of niches they require. The myriad of forest types used by moose in various seasons and life stages are represented by upland ecosite phases b1-3, and d1-2, riparian ecosite phases e1-3 and f1-3, and wetland ecosite phases i1, j1-2, k1-2 and l[58]. Optimizing the patchiness and connectivity of these many habitat types will be challenging.

Some moose in the region appear to move between summer and winter grounds that may be hundreds of kilometres apart, while others stay within a smaller home range (<10 km^2) throughout the year[56]. In particular, migrations occur to and from the Birch and Muskeg Mountains, possibly as a result of heavier snow accumulation at elevations[56]. Elders believe that there is no such thing as a "typical" habitat range for moose, as their movements depend so much on the quality of the habitat and the level of disturbance[55]. Although they can habituate to consistent and non-threatening forms of disturbance (e.g., distant machinery at work), they avoid activity with an element of unpredictability. There is evidence that use of river valleys for movement by moose during the Restricted Activity Period from January to April appears to be lower than at other times of the year[59]. Linear developments like roads and pipelines also increase their vulnerability to wolves and black bears, which can gain access to previously secluded, dense forest stands. Moose calves are particularly vulnerable to predation, with survival rates in the first 8 weeks as low as 17 %[56].

Moose will not necessarily be indicative of the local quality of reclaimed landforms, but they could provide a mechanism or focus for cross-boundary planning of watershed-scale wildlife management. Table D.8 identifies the needs of moose for food, shelter, reproduction, and or migration.

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[54] Peace-Athabasca Delta Project Group 1972

[55] Garibaldi Heritage and Environmental Consulting 2006a, b

[56] Westworth Associates 2002

[57] Westworth Associates 2002; AXYS Environmental Consulting 2003

[58] Bovar Environmental 1998; URSUS Ecosystem Management 2003; Golder Associates 2007

[59] Osko 2003

The impact of the unique mineral composition of reclamation soils on palatability of woody browse and provision of soil licks for moose has not been assessed. This is a research need identified in Section 5.6. Limited information on moose populations in northern British Columbia suggests that moose and other ungulates seek out soil licks to amend more than just tissue sodium concentrations. It may be that bicarbonates, clay and other mineral elements are also beneficial for digestion during seasonal switches from woody to succulent browse[60]. Salt, metal and acid concentrations in woody vegetation may also influence levels of tannins in plant tissues, thereby affecting palatability of browse for herbivores[61]. These are critical uncertainties for herbivore use of reclamation environments.

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[60] Ayotte et al. 2006

[61] Pastor and Naiman 1992; Mattson et al. 2004

Table D. 8 Habitat requirements of moose [56]

Habit	Season	Habitat Requirements
Food	All	Use early seral forests with succulent new growth wherever possible; will move into a burn 2 years after a low-intensity fire; prefer stands 7 – 30 years old
		Eat berries from high-bush & low-bush cranberries, Saskatoon, red willow/dogwood
		Forage habitat should be within 100 m of cover habitat; forage – cover habitat ratio of 65:35 may be optimal, with minimum patch size of 2 – 5 ha (0.02 – 0.05 km^2)[57]
	Spring & Summer	Prefer deciduous browse (leaves), followed by herbaceous (blue joint / goose grass, frog pants/pitcher plant) and aquatic vegetation (pineapple/yellow pond lily leaves & roots)[55]
	Summer & Fall	Often use uplands (aspen, white spruce, jack pine-dominated)[57]
	Fall & Winter	Rely on deciduous browse (twigs, bark); prefer pin cherry, red willow/dogwood, willows, Saskatoon, high-bush & low-bush cranberry, birch, alder, aspen[57]
	Winter	Should have > 30% cover of preferred browse
	Winter & Spring	Often use lowlands (treed bogs & fens) to regain fat reserves after the rut & calving[57]
Shelter/cover	All	Prefer canopy cover >50 %, canopy height >10 m, shrub cover >30 %, >1 km from roads
	Summer	Use water to seek refuge from insects[55]
	Winter	Select mature coniferous-dominated (>40 %) forest with high browse when snow depth is >70 cm
		May congregate in groups of 15 – 20 in river valley bottoms or gentle southern slopes during extreme cold or deep snows
Reproduction	Spring	Calving occurs in areas isolated by dense canopy growth or water: treed bogs & fens, black spruce – willow – tamarack stands, dense riparian forest, islands
	Fall	Use open upland habitat for rut (Sept/Oct) during which time animals eat very little
Travel	All	May use river valley bottoms as travel corridors; should be at least 500 m wide[58]
		Use dense black spruce stands as travel corridors[55]
		Steep or rocky slopes (15 – 45°) may restrict travel; animals can go down but not back up[55]
	Spring & Fall	~40 % of regional population may move > 20 km between summer and winter ranges

D.5.2 Woodland Caribou

Woodland caribou from northern Alberta is a boreal ecotype that resides year round in forested habitat. There are no seasonal migrations from foothills to alpine locations, as there are in south-central populations[62]. Woodland caribou are valued by Aboriginal people from the oil sands region, for subsistence hunting and other traditional activities.

Unlike most of the other priority species described in this appendix, woodland caribou are habitat specialists. They spend more than 80% of their time in lowland forested wetlands, and depend on the arboreal and ground lichens that grow there as staple foods[62]. The forest types used by woodland caribou in the region correspond to wetland ecosite phases i1-2, j1-2, k1 and k3, and mature lowland ecosite phases g1 and h1[63].

Important habitat areas for woodland caribou in the oil sands region have been identified and designated into 10 caribou management zones. Within these zones, discrete herds may occur, but for much of the year, the species resides at very low densities. This is likely a predator-avoidance mechanism[64]. Their preference for lowland wetlands also segregates them spatially from their main predator, wolves, which prefer to use upland habitats. With home ranges typically 500 - 700 km^2 [64], it is unrealistic to expect that a woodland caribou herd will occupy reclaimed habitat exclusively; however, they may be able to use reclaimed landscapes for travel corridors between patches of undisturbed habitat or as extensions of habitat where it abuts core undisturbed territories.

Disturbance by fire or forestry has been identified as a plausible explanation for population declines or changes in territory locations[65]. The terrestrial lichen species (*Cladina* spp.) preferred by woodland caribou throughout much of their range are very slow-growing and take decades to re-establish after forest fires. Similarly extended establishment times may be anticipated for lichen in reclaimed landscapes. Bog and fen reclamation is currently in the research phase, and a pilot-scale fen construction is underway in the oil sands region[66]. Table D.9 identifies the needs of woodland caribou for food, shelter, reproduction, and or migration that must be provided by reclaimed and surrounding environments.

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[62] Westworth Associates 2002

[63] URSUS Ecosystem Management 2003

[64] AXYS Environmental Consulting 2003

[65] Garibaldi Heritage and Environmental Consulting 2006a

[66] Alberta Environment 2008

Table D. 9 Habitat requirements of woodland caribou[63]

Habit	Season	Habitat Requirements
Food	All	Prefer shrub cover >18%, sedge cover >8%, forb cover >11%
		Discontinuous patches of permafrost in raised bogs provide an excellent substrate for terrestrial/caribou lichen growth[64]
	Summer	In summer, diet may be 60% leaves of tree/shrub browse: willows, high-bush cranberry, trembling aspen, balsam poplar, dogwood, bog & white birch
	Summer & Winter	Winter diet is more restricted than summer diet
	Winter	In winter, rely heavily on caribou/terrestrial and arboreal lichens in mature - old growth (> 80y) lowland forests, mostly treed bogs & fens (6 - 70 % tree cover); prefer > 9% lichen cover
		May use upland jack pine forests in winter to browse on arboreal lichen[64]
Shelter/cover	All	Habitats do not differ from those selected for forage
		Use areas > 400 m from roads
Reproduction	Spring	Calving occurs in May in lowland wetlands, probably in similar terrain to moose[65]
	Fall	Rutting occurs in the fall (Sept/Oct); bulls defend the same rutting grounds for many years
Movements	All	May travel up slopes of 15 - 45°, but not down (similar to moose); do not like steep or rocky grades[65]
	Spring & Fall	Seasonal travel restricted mostly to bog and fen habitats
Patch Size	All	May need average patch size of 34 km^2 (3,400 ha) of bog/fen habitat within upland forest[64]

D.5.3 Beaver

The beaver is a semi-aquatic, generalist herbivore that lives in wetlands, lakes and streams of the oil sands region[67]. It has traditionally been an important species for the local trapping and fur industry. The beaver has many predators, and is most vulnerable when moving on land. Bears, wolves, wolverines, coyotes, fisher, foxes, lynx and river otters will prey on adults and young[68].

Aboriginal people refer to the beaver as nature's engineer, because it dams streams to create conditions suitable for lodge-building and safe foraging[69]. In some cases it may dramatically alter the distribution of soil nutrients for decades, because the wetland it creates traps and holds upland nutrients for years before distributing them downstream during dam abandonment and failure[70].

Beaver may also be thought of as a transitional landscape species, relying heavily on elements of both terrestrial and aquatic ecosystems, and on pioneer and mature forest stands. Although beaver live in aquatic environments, they forage in upland or riparian environments, particularly during northern winters when herbaceous vegetation is not available year-round[67]. The forest types that are optimal for beaver forage habitat occur within a few hundred metres of permanent water on gradually sloping terrain, and are dominated by preferred woody deciduous species such as aspen, poplar and willow. These correspond to upland ecosite phases b2 and d1, and other ecosite phases having a predominance of the preferred canopy species (e.g., e1, f1)[71]. Where suitable woody vegetation is present, beaver will construct dams, under-water channels and canals into the riparian zone in order to manipulate the shape and depth of the aquatic environment to suit their needs[68].

Beaver live as extended family units - usually a monogamous adult pair and young from the previous two years - in deciduous wood-constructed lodges or in stream bank burrows[68]. Reproduction is density-dependent, meaning females can and will produce fewer kits where regional beaver densities become high[67]. Optimal beaver habitat can support 0.4 - 0.8 colonies per km^2. Adults will remain associated with a territory for many years, and will only choose suitable aquatic habitat where the adjacent woody vegetation can support years of foraging and lodge maintenance demands[69]. Table D.10 identifies the needs of beaver for food, lodging, protection from aquatic and land-based predators, breeding, and/or dispersal.

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[67] Westworth Associates 2002

[68] Westworth Associates 2002; Garibaldi Heritage and Environmental Consulting 2006a

[69] Garibaldi Heritage and Environmental Consulting 2006a

[70] Naiman et al. 1994

[71] URSUS Ecosystem Management 2003

Table D. 10 Habitat requirements of beaver[67]

Habit	Season	Habitat Requirements
Food	All	Woody species preferred during most of the year are aspen, willow, balsam poplar and alder (twigs, leaves, roots, bark)
		Ease of access and felling is important
		Prefer young pole saplings (61% of trees with dbh < 15 cm), fast-growing, species with less dense wood (e.g., not birch)
		Access to woody forage must be within 100 m of water to reduce predation risk & banks must be navigable (bank height < 1 m, slope < 10°, fine-grained/ stable composition)
		Will use early to mid-seral deciduous forests with single canopy height 7-12 m or mature deciduous forests with diverse canopy height 3-18 m; prefer 40-60 % canopy closure
		Avoid coniferous (spruce, jack pine) trees, birch, slow-growing deciduous trees & shrubs, unless nothing better is available
	Summer	Prefer herbaceous, aquatic vegetation when it is available: pineapple/ yellow pond lily roots, 'underwater banana', pondweeds, grasses[69]
		Summer submergent vegetation cover of 70 % is optimal in lakes with lodges
	Winter	Cache woody food under water at depths that ensure access under ice in winter (>1 m deep); will manipulate/increase water depth by damming if necessary
Shelter/lodging	All	Lodges may be built in wetlands deeper than 1 m, lakes or slow-moving streams; prefer deeper water (1.8 - 2.1 m)[69]
		Bank burrows may be built in stream banks; prefer slow-moving streams (< 15 % gradient, < 10 % riffles) that are longer than 0.8 km
		Streams suitable for beaver dam construction have a channel width of 1-5 m
		Banks for burrows must be composed of fine-grained soils like clay; often built under the roots of a tree or a large rock[69]
		Water must be permanent with a relatively stable hydroperiod (seasonal water level changes < 1 m)
		Lodges are built primarily with poplar and/or aspen[69]
		May need minimum patch size of 2 - 2.5 ha to feel safe[69]
Reproduction	Spring	Litters of 2 - 6 are born in May in lodges or burrows and young have the same habitat requirements as adults
		Nests are constructed of willow bark fibres[69]
Movement/Dispersal	All	Movements from water to woody forage require short land distances (average ~25 m) and gradual slopes for 30 - 60 m
	Spring	Two-year-olds are forced from natal colony in spring & establish territories usually within 10 km; prefer aquatic dispersal routes (downstream), but can move overland through riparian habitat

D.5.4 Muskrat

Muskrat is a semi-aquatic herbivore that lives in wetlands, lakes and streams in the oil sands region. It is a very important fur-bearing species for traditional and subsistence trappers. Populations naturally cycle every 8 – 10 years, probably in response to a combination of factors including mink population dynamics (their main predator), disease outbreaks, and extended periods of drought and drying[72]. Optimal muskrat habitat can support around 40 houses per square kilometre[73].

Aboriginal people say that 'what muskrats feed on, beaver doesn't'[74], which aptly describes the heavier reliance of muskrat on aquatic plants and water insects[73]. Muskrat spend less time in riparian forests than beaver, as they do not eat woody vegetation and use it less in house-building. They are almost exclusively associated with wetland ecosite phases, principally l1 and k3[75]. Cattail may hold greater nutritive value or be a more stable seasonal dietary source than other wetland vegetation; it is the preferred staple food for muskrat, and those habitats dominated by cattail appear to support significantly higher densities (2 – 7 times more animals)[73].

Muskrat may influence the wet-dry cycles experienced in southern (prairie pothole) and northern Alberta marsh wetlands, through impacts of heavy grazing[76]. In reclaimed landscapes, muskrat may need to be excluded until wetland vegetation is well established. Although research suggests that wetland plant species do not take up significant amounts of salts from the water, it is not known whether muskrat and other wetland browsers like beaver and moose will detect a different salt content and avoid these potential forage areas. Muskrat is known to use tidal salt marshes in coastal environments[77].

Muskrats are relatively sedentary, with little seasonal movement away from the area of their houses[73]. Adults build summer and winter houses, bank burrows and winter push-ups for protection while foraging under the ice. Houses and push-ups are constructed of wetland vegetation, often reed grass and cattail[78]. Houses are used for thermal shelter, food storage, protection from predators and raising young. The reliance on emergent and submergent vegetation and their year-round activity limit useful habitat to wetlands with semi-stable water levels, periodic flooding, and depths sufficient to provide an ice-free, underwater foraging zone during the winter. Their sedentary habits make them a good indicator of localized water quality and wetland forage quality. Table D.11 identifies the needs of muskrat for food, lodging, protection from predators, breeding, and or dispersal.

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[72] Westworth Associates 2002; Garibaldi Heritage and Environmental Consulting 2006a

[73] Westworth Associates 2002

[74] Garibaldi Heritage and Environmental Consulting 2006a

[75] URSUS Ecosystem Management 2003

[76] Alberta Environment 2008

[77] Baldwin and Pendleton 2003; Visser et al. 2006

[78] AXYS Environmental Consulting 2003

Table D. 11 Habitat requirements of muskrat [73]

Habit	Season	Habitat Requirements
Food	All	Prefer to forage in sub-climax emergent vegetation (water depths of 0 - 50 cm)
		Optimal forage conditions occur in lakes or wetlands where there is 40 - 70 % emergent vegetation cover & > 75 % submergent vegetation cover
		Prefer to eat cattail, then rat root/sweet flag, burreed, sedges, bulrush, horsetail, reed grass, pondweeds and water milfoil in rough order of preference
		Rat root may be used as both food and medicine[74]
		Emergent vegetation requires semi-stable water levels, periodic flooding, and shallow gradient shorelines
		Will use riparian or shoreline habitat for foraging when wetland vegetation is scarce; these habitats must have > 51% vascular plant cover to be suitable forage areas
	Winter	Eat submergent species, particularly in winter (water depths of 1 - 2 m)
Shelter/Lodging	All	Houses are built on firm substrate (soft tailings not suitable) in ~1 m of water, within close proximity to vegetative cover; made of shoots, roots, rhizomes of emergent vegetation
		Bank burrows may be built where there are steep stream or lake banks; use areas with solid (often clay) banks ≥ 10°, flows < 10 m/min & good cover from dense, over-hanging riparian shrubs or thick moss[78]
	Spring	During high water/flooding, houses may be built in riparian willow stands
	Fall & Winter	Push-ups (mounds of dead vegetation) are built after fall freeze-up over holes in the ice, to extend winter foraging[74]
		Location of structures is most limited by water and ice depths
	Winter	The critical ice/water depth to prevent freeze-outs is 60 - 75 cm; depths ~1.2 m may be optimal[74]
Reproduction	All	River territories may support higher survival rates for young
	Summer	Muskrats give birth in houses in June or July[74]
Movement/Dispersal	Spring	Dominant females force out males and sub-adults in spring; prefer to disperse using streams, but will move overland through riparian habitat if necessary

D.5.5 Red-backed Vole

Red-backed vole is a nocturnal omnivorous rodent present in a variety of upland and lowland forest habitats in the oil sands region. It is a critical prey species, along with snowshoe hare, for a number of small mammal and avian predators. In particular, fisher depends on this vole and the hare as staple foods[79]. Red-backed vole densities cycle in response to hare-fisher dynamics. Red-backed voles and other small rodents with similar diets also play a role in forest growth, as they feed on ectomycorrhizal fungi and distribute fungal spores to new forests[80]. Ectomycorrhizal fungi are a key symbiont of many boreal tree species and significantly enhance their growth by delivering more soil nutrients to the roots[81].

As a small prey species, red-backed vole lives where it has sufficient cover to escape predation. As such, the species is frequently associated with mature forests having complex forest floor structure: rotting wood, downed wood, abundant litter. However, they may be found in other forest types provided there is cover and moisture present[82]. Forest types known to support red-backed voles include upland ecosite phases b1, b3, b4, d1 and riparian ecosite phase e1[83].

Information on many aspects of the vole life cycle is not known[84]. Table D.12 describes the basic habitat needs for red-backed vole. Their dispersal is limited when habitat patches are separated by clearings[85], thus connectivity with immigration sources will be required before they will establish in reclaimed landscapes[85].

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[79] Westworth Associates 2002

[80] Morrison et al. 1992

[81] Raven et al. 1981

[82] AXYS Environmental Consulting 2002; Pearce and Venier 2005

[83] Bovar Environmental 1998

[84] McTaggart-Cowan and Guiguet 1973

[85] Gillis and Nams 1998

Table D. 12 Habitat requirements of red-backed vole [82]

Habit	Season	Habitat Requirements
Food	All	Forage at night for fungi, lichens, seeds, berries, bark, petioles of leaves, shrub buds, wildflowers, invertebrates & carrion
		Seek out hypogeous (underground) fungi under rotting logs for food and water
	Summer	May prefer berries from blueberry, bog cranberry & bearberry/ stoneberry[84]
Shelter/Cover	All	Prefer balsam poplar, trembling aspen or jack pine-dominated stands with abundant litter and deadfall[79]
		Prefer dense understory of red willow/dogwood, currant, alder or raspberry & abundant feather mosses
		Prefer large diameter trees in canopy, > 60 % canopy closure
Reproduction	Spring & Summer	Nest is a simple platform, usually located under roots or litter; sometimes underground[84]
Movements	All	Travel through moss or duff, or use fallen debris
Patch size	All	Occupy small territories (0.1 ha), but may require minimum patch size of 2 ha (0.02 km^2) to feel safe from predation[83]
		Forest gaps equivalent to a home range diameter (60-70 m) may prevent dispersal to new habitat patches[85]

D.5.6 Snowshoe Hare

Snowshoe hare or jackrabbit is a common nocturnal herbivore throughout the northern boreal forest. It is the dominant prey for many species, including the lynx, which is an obligate predator of the hare[86]. The 10-year population cycles for snowshoe hare are well documented, and trigger responsive cycles in populations of many predators and alternative prey species (such as the red-backed vole). Thus, the quality of habitat for snowshoe hare impacts not only on the hare, but on many small- to mid-size carnivores (owls, fox, coyote, wolf, fisher, lynx) and their prey[87].

The habitat used by snowshoe hare broadens and contracts with the rise and fall of the effective population. When numbers are low, hare retreat to their preferred habitat, which offers quality browse in a protected setting. These refugia from predators tend to be located in dense black spruce stands, willow - alder thickets, or other young thick stands of conifers[88]. Populations expand out of these habitats into surrounding areas with less suitable cover but abundant browse. The forest types used by snowshoe hare are numerous; the optimal habitat corresponds to upland ecosite phases b4, d1 and d2, and riparian ecosite phase g1[89]. These forest types ideally would be surrounded by other stands offering abundant browse.

Home range sizes for hare can be as large as 12 ha, but most individuals frequent an area of just 3 ha[86]. Their sedentary nature and the predictability of their population cycle may make this species a useful indicator of the stability of the local prey base for a number of wildlife food chains. Their reliance on early seral forests with an abundance and diversity of shrubs, and the often patchy nature of these stands also implies that many of their needs broadly overlap with those of other generalist herbivores, including moose.

As with many wildlife species in the boreal forest, forage and cover availability for hare are far more restricting in winter than summer. Thus, attention to seasonal changes in these two key survival determinants must be made during planning for reclamation landscapes. The placement of coarse woody debris may provide opportunities for denning, cover and security on reclaimed landscapes. The direct placement of LFH will also provide for establishment of shrub cover and allow for reductions in planting densities of understory species (see Appendix G). Table D.13 identifies the needs of snowshoe hare for food, cover, and/or travel.

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[86] Westworth Associates 2002

[87] Westworth Associates 2002; Garibaldi Heritage and Environmental Consulting 2006a

[88] AXYS Environmental Consulting 2003

[89] Bovar Environmental 1998

Table D. 13 Habitat requirements of snowshoe hare (jackrabbit) [86]

Habit	Season	Habitat Requirements
Food	All	Use young (~ 10 y) coniferous, deciduous or mixedwood stands with a well developed shrubby understory 0.5 – 1.5 m high (> 71 % shrub cover)
		Palatable browse species should represent > 17 % of total cover: white spruce, aspen, birch, willow, rose, alder, Saskatoon, tamarack/larch, jack pine, raspberry, buffalo-berry[88]
		Avoid unpalatable species: black spruce, muskeg/Labrador tea, honeysuckle, buckbrush/snowberry
	Summer	Browse includes forbs, grasses, leaves, bog birch, green alder, willow, rose, blueberry, low-bush cranberry, Saskatoon, fireweed, horsetail
	Winter	Browse includes willow, aspen, poplar, birch (buds, twigs & bark), white spruce needles; prefer twigs < 3 mm diameter[87]
Shelter/Cover	All	Cover from predators may be provided by coniferous canopy, understory shrubs or downed woody debris
		Prefer > 35 % shrub cover, 0.5 – 3 m in height
		Prefer 50 – 60 % conifers in canopy with total cover > 31 % (< 70 % to allow for shrubby understory), canopy height > 3.5 m[88]; prefer spruce-dominated stands
		Prefer downed woody debris cover of 11 – 15 %
		Do not build a nest; shelter under brush or trees
	Winter	Do not use deciduous-dominated stands or areas with understory < 40 % above snow level
		Thermal cover provided best by dense coniferous stands
Reproduction	Spring	Habitat does not differ from cover habitat
Movements	All	Cover should be within 400 m of forage site; will travel in more open habitats in summer than in winter & during population highs
Patch Size	All	Minimum patch size of 0.1 km^2 (10 ha); prefer edge habitats and high interspersion of habitat patches[88]

D.5.7 Black Bear

Black bear is one of the largest omnivores in northern Alberta, and is relatively abundant in the oil sands region compared to the rest of the province. It is a powerful spirit animal for local Aboriginal people. It is also hunted for meat and medicine, and is one of the main big game species for the area. Aboriginal people believe that the regional population is currently at a low[90]. Black bear have reasonably large home ranges, up to 120 km^2, and are considered to be habitat generalists, like moose[91]. Their diet is largely vegetation (~80 %), but they do also opportunistically eat fish, moose calves, invertebrates, carrion and garbage[92].

The greens and berries that are their staple foods are found most abundantly in early seral forests having diverse shrub understories interspersed with small clearings. However, black bear territories must also contain sites that are suitable for denning. These include over-wintering den sites, which are often located in mature, well-drained forests[91] but black bears can be highly adaptable and may also establish den sites in a hummock in a bog, a cave, and within trees and roots that have fallen-over along a river valley. The numerous forest types that meet part or all of their habitat requirements correspond to upland ecosite phases a1, b1-4 and d1-3 and riparian ecosite phases e1-3 and f1-3[93]. Generally, black bear use upland and riparian habitats and avoid lowland bog and fen habitats[81].

Black bears do not undergo a true hibernation, but their metabolism slows significantly as they sleep through the winter months in ground dens. Dens are also used for the birth and rearing of cubs. The late maturation age (4 - 6 years) and low rate of reproduction (average litter size of 2 every second year) contribute to slow rates of population recovery for black bears when many adults are lost through starvation or over-hunting[81]. Loss of berry-producing and denning habitat through mining may also produce population reductions if alternative quality habitat is not present within individual territories.

The seasonal variability in forage preferences can be substantial, even though bear do not forage routinely during the harshest winter months. New green grass and forb growth in spring will bring bear out into more open habitats that they would not otherwise venture into, while the high sugar content and digestibility of berries helps to prepare bear in early fall for the lack of regular food intake over winter[82]. Table D.14 identifies the needs of black bear for food, cover, over-wintering, reproduction and/or travel. The large territories occupied by this species may necessitate cross-boundary planning to coordinate the availability of the varying forage and den habitats in a given home range.

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[90] Garibaldi Heritage and Environmental Consulting 2006a

[91] Westworth Associates 2002

[92] Westworth Associates 2002; Garibaldi Heritage and Environmental Consulting 2006a

[93] Bovar Environmental 1998; URSUS Ecosystem Management 2003; Golder Associates 2007

Table D. 14 Habitat requirements of black bear [86]

Habit	Season	Habitat Requirements
Food	All	Prefer early seral mixedwood stands with well-developed understory containing > 31% berry-producing shrubs
	Spring	Forage in open areas (cutblocks, seismic lines, meadows) for newly emerged greens: prefer peavine/vetch pea, horsetails, grasses, sedges, dandelions, catkins of aspen & balsam poplar, cattail roots
		Will kill moose calves, scavenge carrion/garbage
	Summer & Fall	Switch to berries, nuts, insects (ants, bees), roots (willow, poplar) and herbs
		Eat berries of blueberry, Saskatoon, low-bush cranberry, buffalo-berry, rose, currant, raspberry, bearberry/stone berry, chicken-berry/ bunchberry, wild sarsaparilla, red willow/dogwood[90]
	Fall	May move to spawning sites in fall[90]
		Preferred fall berries are blueberries, cranberries[90]
Over-wintering	Winter & Spring	Den underground in well-drained soils, easy to excavate in mixedwood stands
		Dug to depths of 30 cm – 1.5 m[90], usually under root masses/trunks of fallen trees
		May also use caves on rocky hillsides, often north-facing (retain snow for thermal cover, water source in spring)[90], or hummocks in bogs and fallen-over trees and roots along river valleys
		Den entrances are camouflaged with moss, dried grass, located near standing trees (escape cover for cubs)[90]
		Typically located at home range boundary, re-use every year unless disturbed[90]
		Prefer mature (> 80 y) white spruce, white spruce – aspen, or jack pine stands
		May locate near riparian forest, for access to water in winter
		May abandon den if disturbed[90]
Shelter/Cover	All	Prefer mature mixedwood stands with > 51 % canopy cover & good climbing trees (diameter at breast height >15 cm) for escape from other bears, wolves
Reproduction	Winter & Spring	Cubs are born in dens (Jan – Feb), live with sow for 2 winters
		Use grasses from peatland wetlands to line dens as well as leaves, litter[90]
Movement/Dispersal	All	Prefer to travel through habitats that provide good cover (see above)
		Will travel on steep slopes (3:1)[90]

D.5.8 Lynx

Lynx is the only common wild cat in northeastern Alberta. The pelt is the most highly valued in the local fur trade, and thus it is an important species for trappers[94]. It is also an obligate predator of snowshoe hare[95], and is important in the maintenance of ecological balance among wildlife in young, establishing forests.

Lynx depend on hare as a staple food (it makes up 35 - 97% of their total diet) and thus the two species coexist in the same types of forage habitat[95]; however, the reproductive and travel needs of lynx cannot be met within the early seral forests in which they forage. Reproduction typically occurs in mature forest stands, whereas travel between multiple den sites, and den and forage sites often occurs through intermediate age stands[95]. The forest types used by lynx that differ from those of the snowshoe hare (see section D.6) correspond to upland ecosite phases a1, b1 and d3, riparian ecosite phases e1-3, lowland ecosite phases g1 and h1, and wetland bog and fen ecosite phases i1-2, j1-2 and k1[96]. Optimal habitat for lynx contains mature (> 20 y), dense forest stands interspersed with good snowshoe hare habitat[97].

Lynx populations cycle with a lag time of 1 or 2 years behind snowshoe hare peaks and crashes. Hare numbers reportedly affect not only population size of lynx, but also their home ranges and reproductive rates. Average home ranges of less than 40 km^2 will expand to hundreds of square kilometres when hare numbers fall[98]. Also, lynx productivity drops due to reduced survival of kittens and lower rates of conception among young females[95].

Lynx use dens when giving birth to their kittens. To reduce predation risks, lynx maintain multiple den sites and move the kittens from one to another when threats arise. There is some evidence that lynx occupying habitats unsuited to multiple den sites experience lower rates of kitten survival[95]. This protection strategy requires that there be more than one patch of mature forest, and that patches be connected by intermediate age stands preferred as travel corridors.

As with many other wildlife species in the region, winter is the most difficult season for lynx. Lynx kill rates are affected by snow depth and the seasonal habits of their buffer prey species. Although hare remain active during the winter, other prey such as red-backed vole, mice and squirrels are inaccessible under the snow or are less active. When their range must be expanded because of harsh weather or low hare numbers, the connectivity of habitat can be a critical determinant of habitat quality. Lynx dislike crossing open areas wider than 100 m and will be less likely to use suitable habitat if it occurs in isolated patches[93]. Table D.15 identifies the seasonal needs of lynx for food, cover, reproduction and/or travel.

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[94] Garibaldi Heritage and Environmental Consulting 2006a

[95] Westworth Associates 2002

[96] URSUS Ecosystem Management 2003

[97] AXYS Environmental Consulting 2003

[98] Westworth Associates 2002; Garibaldi Heritage and Environmental Consulting 2006a

Table D. 15 Habitat requirements of lynx [95]

Habit	Season	Habitat Requirements
Food	All	Snowshoe hare is principal prey; buffer species include mice, voles, squirrels, chicken/grouse, ptarmigan, ducks, marten, fish, frogs, carrion & deer or caribou fawns[94]
		Local populations may eat a lot of chicken/grouse[94]
		Prefer sites < 100 m from cover habitat
		Dense shrub cover (> 70 %) may limit hunting success
	Winter	More restricted diet; may use riparian deciduous-dominated forests (early winter) and black spruce/jack pine forests (mid-/late-winter) more often
Shelter/Cover	All	Use mature mixedwood stands (> 20 y) as well as younger stands with structural complexity
		Prefer canopy closure 50 - 70 %
		Dominant tree species are often white spruce, jack pine, trembling aspen, balsam poplar[97]
		Prefer stands with well-developed shrub understory (shrub canopy cover 30-70 %); dominant species are often dwarf birch, willows, Labrador tea, bearberry[97]
		Shrub cover > 71 % may limit access for adults
Reproduction	Summer	Den location is most dependent on the density of cover (amount of large, inclined woody debris); most often occur in mature – old coniferous or mixedwood forests
		Dens may be in rotten logs, beneath fallen tree roots/trunks, in rock crevices or in surface scrapes; may also use abandoned coyote dens[94]
		Prefer forest stands with > 1 log/1.6 m of forest floor, lying 0.3 – 1.3 m above ground
		May prefer north-facing slopes[97]
		Prefer sites close to young stands (< 500 m, for foraging) & intermediate stands (for travel) with minimal human activity (> 250 m away)
		Den habitat minimum patch size may be 1 – 2 ha (0.01 – 0.02 km^2)[97]
Movements	All	Usually will not cross cleared forest gaps > 91 m wide[97]
	Summer	Prefer to move kittens through intermediate aged stands with deciduous or coniferous canopy > 2 m, high canopy closure, open understory, density of 420 – 640 trees per ha (~40,000 – 60,000 per km^2)[97]
	Fall & Winter	1-yr-old dispersing juveniles and hungry adults may move several hundreds of kilometres

D.5.9 Fisher

Fisher is a large, tree-dwelling weasel present in the boreal forest region. It is an important fur species for local trappers[99], and its continental population is probably more regulated by over-harvesting than by other mechanisms[100]. It has few natural predators. Habitat loss is the other main reason for population reductions[96].

Fisher is a generalist predator or scavenger, eating mostly small mammals and, in particular, snowshoe hare and red-backed vole. Hence, there is some overlap in the forest types occupied by fisher, hare and vole. However, the niche believed to be most limiting for fisher is that for rearing of their young. Fisher females are very selective in their choice of dens, which are often located in deciduous tree cavities in older, large diameter decaying or dead trees[96]. The forest types used by fisher while foraging, nesting, travelling or resting correspond to upland ecosite phases a1, b1, b3, b4, d2 and d3, riparian ecosite phases e2, e3, f2 and f3, and lowland ecosite phases g1 and h1[101].

The den selection habits of fisher imply that it is dependent on late-seral forest stands to meet reproduction and sleeping needs. However, there is some question about whether fisher is truly limited by the occurrence of mature forests[96]. A complexity of forest structure within younger stands may be sufficient, given the ability of fisher to exploit many different species as prey. Fisher require a high diversity of dense prey populations that are vulnerable to capture by a large, tree-climbing weasel, and sites for natal and maternal dens and resting nests. Maternal dens are most often located in decaying trees, but may also be situated in rock crevices, brush piles or under boulders[96].

Fisher, like lynx, prefers to maintain more than one den site. In addition, fisher females usually move their kits from natal to maternal dens around 4 - 6 weeks of age[96]. Adult males and females use specific resting nests as well, when on foraging rounds. Fisher home ranges tend to be as large as lynx, around 15 - 40 km^2, and Aboriginal people contend that, outside of the breeding season, they travel that territory in circuits[99].

Although fisher is not a migratory species, it travels as other predators do in search of prey[95]. Like lynx, fisher require a contiguous distribution of forested habitat patches to move about their territory unhindered and generally avoid crossing open spaces[102]. Landscape patterning is an important element of reclamation design for these small mammal predators. Table D.16 identifies the seasonal needs of fisher for food, cover, reproduction, resting sites and/or travel.

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[99] Garibaldi Heritage and Environmental Consulting 2006a

[100] Westworth Associates 2002

[101] Bovar Environmental 1998; URSUS Ecosystem Management 2003; Golder Associates 2007

[102] AXYS Environmental Consulting 2003

Table D. 16 Habitat requirements of fisher [100]

Habit	Season	Habitat Requirements
Food	All	Prefer areas with a high diversity of small mammals
		Prey is predominantly snowshoe hare and red-backed vole, but also includes red squirrel (hard to catch), mice, shrew, porcupines, grouse/chicken, young birds, fish, invertebrates, fruit, nuts, large mammal carrion[99]
		Prefer relatively large stands of mixedwood with coniferous-dominated patches (> 50 – 90 % canopy cover)[102], abundant coarse woody debris (> 20 cm diameter, > 30 / ha), snags
		Use coverts (thick stands of young conifers and windfalls on ridges) to hunt for snowshoe hare, grouse/chicken, squirrels[102]
		Prefer stands with well-developed shrub cover (41 – 60 %) & varied ground cover
		Structural diversity in riparian and edge habitats provide good hunting grounds
		Minimum patch size for foraging may include width of 25 m and overall size of 2 km^2 (200 ha)[102]
	Winter	Prefer dense coniferous stands (white & black spruce) to hunt when snow limits speed, or more open deciduous stands if a weight-bearing crust has formed on the snow[102]; rely more heavily on carrion and chicken/grouse
Shelter/Cover	All	Resting sites are typically located in tree cavities, snags or rotting logs in lowland mature coniferous or mixedwood forests
		Resting sites may also be in 'witches broom' in conifers, snow dens, ground burrows, under rocks, tree roots, woody debris, squirrels' nests, raptors' nests
		May habituate to predictable disturbance
		Prefer sites in trees in spring & fall, and ground sites in winter
Reproduction	Spring	Prefer to make dens in deciduous tree cavities and snags, but will also use rock crevices, brush piles and boulders
		May prefer aspens for tree cavities; may use nests of red squirrel[99] or pileated woodpecker
		Maternal den sites are often located near mature, live, standing trees
		Prefer mature mixedwood forests with > 41 % trees having a diameter at breast height > 10 cm, canopy height >15m
Movements	Winter	1-yr-olds disperse up to 50 km in late winter
		Dispersal and other long-range travel probably occurs through riparian forests

D.5.10 River Otter

River otter is a semi-aquatic mammal that inhabits streams, rivers, lakes and open wetlands in the oil sands region. Of the indicator wildlife species in this appendix, it best represents moving water and lake habitats. It is closely associated with beaver and muskrat, which are not only prey species, but often provide den sites for resting and reproducing[103].

River otter territories and movements are typically linear (~10 km), as they occupy and defend mostly stream or shoreline environments. However, riparian forests adjacent to these waters are important for shelter, protection and foraging movements. Otter will take the shortest, known route from one familiar water body to another, even when it requires travelling overland up to 3 km[104]. The forest types in which otter may be active correspond to riparian ecosite phases e2, e3 and f1, and wetland ecosite phases k3 and l1[105]. Any riparian ecosite phase that is adjacent to water and has a reasonable understory cover, particularly of willow and alder, could be used by otter.

River otter is considered an opportunistic predator. Fish and aquatic invertebrates are the dominant food sources in most areas[106], although these are not easily available throughout all seasons. Small mammals and moulting waterbirds can also make up a substantial portion of the diet. Like fisher, the otter's generalist feeding strategy makes it less susceptible to cyclic reductions in prey species. As such, their occupation of reclaimed habitat is more likely to be limited by availability of dens or connectivity of aquatic environments.

River otter live as small, social family units. Optimally, otter dens are located underground with underwater entrances. Since they do not usually construct their own dens, it is likely that river otter will arrive in a suitable aquatic habitat after occupation by muskrat or beaver and take over a bank burrow or lodge from these other two species[103]. Riparian stands with diverse floor structure, including downed trees and rock or brush piles, may provide sufficient den sites without the presence of beaver or muskrat. Where river otter populations decline from loss of habitat they are often slow to recover. River otter females produce a low number of pups each year (1 to 4) and males are late breeders (mature at 2 y, but often don't breed successfully until 5-7 y)[99]. Table D.17 identifies the needs of river otter for food, cover, reproduction, and/or travel.

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[103] Westworth Associates 2002

[104] Westworth Associates 2002, Garibaldi Heritage and Environmental Consulting 2006a

[105] URSUS Ecosystem Management 2003

[106] Garibaldi Heritage and Environmental Consulting 2006a

Table D. 17 Habitat requirements of river otter [103]

Habit	Season	Habitat Requirements
Food	All	Prefer slow-moving coarse or abundant fish species due to ease of capture: brook stickleback, northern/jack pike, white sucker, arctic grayling, lake whitefish[106]
		Also eat aquatic invertebrates, waterbirds, muskrat, beaver, snowshoe hare, frogs & toads, mice[106]
		Cover of emergent/submergent vegetation is important determinant of prey density and capture success
		Eat rat root/sweet flag[106]
	Winter	In winter, prefer to forage in areas of open water (must come to shore to breathe and rest where there is ice)
Shelter/Cover	All	Most vulnerable on land; prefer riparian forest stands dominated by willow, poplar, birch, spruce; other common species include red willow/dogwood, snowberry/buckbrush
		Prefer wetland habitats with good shoreline cover of cattails, sedges, horsetail, grasses
		Prefer den sites where bank understory cover is > 25%
		Dens used for shelter must be dry, but prefer underground burrows with underwater entrance
		Prefer muskrat/beaver bank burrows or beaver lodges, but will also use naturally undercut banks, tree root/log cavities, rock crevices
		Dens are usually within 10 m of shoreline
		May need minimum patch size of undisturbed area of 2.5 - 4 ha around stream[106]
Reproduction	Spring	Pups are born in dens; requirements not different from adults
Movements	All	Movements are linear, along streams, shorelines or across land between known water sources
		Prefer water with deep areas for escape[106]
		When using riparian areas, prefer understory cover > 25 % dominated by alder or willow; canopy cover often dominated by aspen or white spruce

D.5.11 Old Growth Forest Bird Community

Old growth forests are uncommon in terms of aerial extent within the oil sands region[107]; however, they provide habitat for a unique wildlife community that is not well accommodated by other forms of habitat. Old growth forests include deciduous or mixedwood stands that are older than 100 years, and coniferous stands that are older than 120 years[107]. These forest types correspond to upland ecosite phases b1, b3, b4, d2 and d3, and riparian ecosite phases e2, e3, f2 and f3[108].

Many species use these forests, but there are a few bird species that are wholly dependent on them for survival and reproduction. Of these, nine occur within all of the major old growth forest types present in the oil sands region. They are: bay-breasted warbler, black-throated green warbler, Cape May warbler, golden-crowned kinglet, ruby-crowned kinglet, red-breasted nuthatch, brown creeper, winter wren, white-winged crossbill and western tanager[109]. These species can indicate the functional integrity of old growth forests in the region[110] and this section will focus on their general group requirements as well as species-specific requirements for habitat. The boreal owl and pileated woodpecker may also be considered as representative of old growth forest bird communities and their needs are discussed separately in sections D.14 and D.15.

Most of these priority species are insectivores (some secondary reliance on other invertebrates, fruit or berries) and their population sizes vary widely with outbreaks of spruce budworm. The white-winged crossbill is a seed-eater and, although resident in the oil sands region, it wanders widely and populations fluctuate widely with cone crop sizes[109]. The red-breasted nuthatch, white-winged crossbill and western tanager are considered common in the northern boreal forest, whereas the other six priority species are considered uncommon. Several of these species have quite secretive habits, particularly the brown creeper and bay-breasted warbler, thus they can be difficult to monitor. Table D.18 describes what is known about the general and species-specific habitat requirements of this community of old growth forest birds.

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[107] Westworth Associates 2002; URSUS Ecosystem Management 2003

[108] Bovar Environmental 1998; URSUS Ecosystem Management 2003

[109] Westworth Associates 2002

[110] AXYS Environmental Consulting 2002

Table D. 18 Habitat requirements of old growth forest passerine birds [109]

Species	Season	Habitat Requirements
Universal needs	All	60 m wide riparian strips for interior-dwelling forest species[110]
		Minimum forest patch size is 10 ha (0.1 km^2), 15 ha in developed/harvested landscapes[110]
		Species diversity is reduced in forests smaller than 187 ha (1.9 km^2)[110]
	Spring	White spruce are important as song-posts for a number of species, and as foraging stations[110]
	Fall	Juvenile dispersal occurs in riparian habitat, along stream buffer strips[110]
Brown creeper	All	Often inhabit mixedwood stands containing trembling aspen, balsam poplar and birch, but prefer stands with > 60% spruce, fir and larch
		Prefer overall canopy closure > 60% and > 70 stems/ha dead, damaged or diseased
		Avoid disturbed sites
	Summer	Nest mostly in coniferous trees under loose bark (rarely in cavities), 1-15 m above ground, canopy height > 17 m
Red-breasted nuthatch	Summer	Nest by excavating cavity in mostly dead trees or snags, 0.5 - 20 m above ground
		May also use abandoned woodpecker and chickadee cavities as well as natural holes
		May prefer mixed coniferous stands
Winter wren	Summer	Nest in moist (riparian) forests with dense underbrush and fallen trees (> 8% coarse woody debris)
		Nest near the ground in dense undergrowth along forest edges, in root tangles, crowns of fallen trees or slash
		Prefer canopy height > 20 m & > 60% spruce/fir composition
		Prefer canopy closure > 45 %
Golden-crowned kinglet	Summer	Nest in highest densities in spruce/fir-dominated stands (> 50%, particularly white spruce - aspen), 4.5-15 m above ground
		Prefer stands with canopy height > 20 m, closure > 50%
Ruby-crowned kinglet	Summer	White spruce used when foraging[110]
		Avoid snags and ground while foraging[110]
Bay-breasted warbler	Summer	Nest in closed white spruce-dominated stands, 0.5-15 m above ground
		Avoid disturbed sites, prefer interiors rather than edges
Black-throated green warbler	Summer	Nest mostly in coniferous trees, 1-20 m above ground, canopy cover > 40%
		Paper birch, trembling aspen/balsam poplar are also used for nesting and foraging, but deciduous-dominated stands should contain 10-20 % white spruce
		Prefer moist (riparian) ecosites with dense shrub cover
		25-40 m wide openings in forest reduce breeding birds' ability to defend territory; avoid edges and small isolated patches[110]
		Minimum patch size may be as low as 0.1 ha (~200 trees) if patch is surrounded by 30-60 year forest stands
Cape May warbler	Summer	Nest in dense stands of white spruce within larger forests (canopy height > 10 m, > 50 % conifers), 10 -18 m above ground
		Prefer sites with several tall white spruce rising above canopy, possibly for use as song-posts
		Use edge habitats & prefer stands with open understory
Western tanager	Summer	Nest in open forests (6-85 % canopy closure), up to 15 m above ground
		Prefer stands with > 15% conifers, canopy height > 12 m, but avoid very dense coniferous stands
		Prefer understory with > 15% berry-producing shrubs
		Prefer upland habitats with mesic - dry soil moisture regimes
White-winged crossbill	Summer	Nest in closed black or white spruce-dominated stands (with aspen or alder mix), 1-20 m above ground

D.5.12 Mixed Wood Forest Bird Community

Mixed wood forests are an important bird habitat in the oil sands region. They are characterized by a diverse mix of deciduous and coniferous trees in the canopy. That mix creates diversity in understory light regimes and understory plants. Varied vegetation structure and community composition result in a great variety of niches for wildlife. Since several of the old growth forests described in section D.11 are also classed as mixedwood, there is some overlap in ecosite phases and bird species that inhabit these two community categories. However, the mixedwood forest also includes young mixed stands (<80 y). The main mixedwood forest types present in the oil sands region may be described as upland ecosite phases b1, b3, b4, d2 and d3, riparian ecosite phases e2, e3, f1, f2 and f3 and lowland ecosite phase h1[111].

In addition to several of the bird species identified as dependent on old growth (brown creeper, red-breasted nuthatch, winter wren, black-throated green warbler, Cape May warbler, western tanager, white-winged crossbill, boreal owl, pileated woodpecker), there are five other species that are representative of the habitats encompassed by mixedwood forest stands. These five species are: black-capped chickadee, blue-headed vireo, blue jay, Canada warbler, magnolia warbler, rose-breasted grosbeak and yellow-bellied sapsucker[112]. Aboriginal communities have also expressed concern for other songbirds that inhabit these forests, particularly the whiskey jack (also called the gray jay)[113]. Therefore, information will be included for this species, where it is available.

Most of these priority species are migrants, present in the oil sands region only from mid-spring to early fall. The black-capped chickadee, blue jay and whiskey jack are resident year-round; however, during particularly hard winters, these birds will also move southwards out of the region[112]. There is little empirical data on population sizes of these species in Alberta; limited information suggests that most of them are common, with the exceptions of the blue jay, blue-headed vireo and Canada warbler (the last is listed as 'sensitive' and thus needing some level of special management or protection). Table D.19 describes what is known about the general and species-specific habitat requirements of this community of mixedwood forest birds.

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[111] URSUS Ecosystem Management 2003

[112] Westworth Associates 2002

[113] Garibaldi Heritage and Environmental Consulting 2006a

Table D. 19 Habitat requirements of mixedwood forest passerine birds [112]

Species	Season	Habitat Requirements
Black-capped chickadee	All	Use stands with poplar, willow and spruce[113]; use coniferous trees more in winter & deciduous more in summer, but tend still to over-winter in the nesting territory
	Summer	Nest by excavating cavities in deciduous trees, usually ones that are dead with broken tops, canopy height > 10 m
		Occasionally will nest in woodpecker holes or nest boxes
		Prefer trembling aspen stands with 1.5 snags/0.4 ha & tree diameter at breast height of 10 - 25 cm
		Prefer overall canopy closure of 40 - 90%
Blue-headed vireo	Summer	Nest most often in saplings or coniferous trees, < 4.5 m above ground, canopy closure > 75 % (open understory)
		Frequently use forests dominated by jack pine for nesting
		Prefer edge interfaces between forest stands of varying heights/ages
		May require large forest patches (minimum size not known)
Blue jay	All	Prefer edge to interior forest habitats
	Summer	Nest in coniferous trees, 2.4 - 7.5 m above ground
Whiskey jack[113]	All	Prefer stands with spruce and poplar, developed understory
	Summer	Nest in large bushes and jack pines
	Winter	Use woodpecker cavities to store seeds over winter
Canada warbler	Summer	Nest on or near (< 4 m) the ground in decaying woody debris, clumps of moss, roots of live trees or in coniferous saplings
		Prefer moist (mesic/riparian) soil conditions, dense under-stories (> 1.5 m) and canopy height > 10 m
		May prefer sites with slope > 15°
		Use deciduous-dominated forest edges for nesting and foraging where the shrub layer is well developed
Magnolia warbler	Summer	Nest in dense young coniferous or mixedwood stands or in mature stands if the understory is dense, < 4 m above ground
		May prefer dense spruce stands adjacent to deciduous stands, edges between coniferous and deciduous stands
		Prefer to nest near water
Rose-breasted grosbeak	Summer	Nest in deciduous trees or shrubs, 1.5 - 4.5 m above ground
		Prefer sites with tall shrubs, dense understory
		Use shrubby edges, riparian thickets, second growth stands, particularly aspen and poplar
Yellow-bellied sapsucker	Summer	Nest in cavities in mostly deciduous trees, particularly birch, aspen & poplar, < 12 m above ground, in trees > 15 cm in diameter at breast height
		Will return to and re-use excavated cavities for years
		Prefer to nest along forest edge, near water

D.5.13 Ruffed Grouse

The ruffed grouse or drummer is the second most abundant upland game bird in the oil sands region, after the spruce hen or grouse. It is valued by both subsistence and recreational hunters. It is also an important prey species for a number of predators, including owls, hawks and lynx. It gains importance as an alternative prey to the snowshoe hare in years when the hare population is at cyclical lows. Grouse populations also cycle periodically and influence predator-prey dynamics[114].

The ruffed grouse (drummer or chicken) is resident in the region. Individuals are relatively sedentary (home ranges are usually just a few hectares), males will often defend the same breeding territory for a lifetime[114], and thus, the species can be a useful indicator of localized habitat quality. The species is typically associated with deciduous and mixedwood upland forests, and the most important habitat element is the presence of aspen-dominated stands of varying ages. Upland forest types used include ecosite phases b1, b2, b3, d1 and d2. Riparian habitats may be used when suitable upland is not available, or as travel routes for juvenile dispersal; riparian ecosite phases used include e2, f1 and f2[115]

Ruffed grouse use different niches, depending on the season and their age. Optimal habitat occurs where all of their requirements are met within a 4 ha area[114]. Although classed as omnivores, only very young chicks depend heavily on a food source other than vegetation; in the first few weeks of life, chicks eat mainly arthropods such as insects, millipedes, centipedes, spiders, mites, ticks, pill bugs and wood-borers. Table D.20 identifies the needs of chicks, juveniles and adults for food, cover, breeding, and/or dispersal.

In addition to the drummer, Aboriginal communities voiced a knowledge and value placed on all 'chickens' found in the region[116]. This includes the more common spruce hen or grouse, sharp-tailed grouse, gray chicken or partridge, and willow ptarmigan. Sharp-tailed grouse and ptarmigan are believed to be less abundant in the region than during the mid-1900's[116]. Their habitats differ considerably from the ruffed grouse or drummer, and the habitat account presented here is not representative of chickens as a whole.

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[114] Westworth Associates 2002

[115] Bovar Environmental 1998; URSUS Ecosystem Management 2003

[116] Garibaldi Heritage and Environmental Consulting 2006a

Table D. 20 Habitat requirements of drummer (ruffed grouse) [114]

Habit	Season	Habitat Requirements
Food	Summer	Diet includes berries (stone-berry / bearberry, raspberry, blueberry, chicken-berry/bunchberry), greens (sedges) & insects[116]
		Chicks depend on arthropods (50-75 % of diet) for the first 2-5 weeks after hatching
		Arthropods (mites, ticks, spiders, insects, centipedes, etc.) are abundant in clearings or young aspen stands (< 10 y)
	Winter	Diets depend on presence of mature aspen (25 - 80 y) in forest canopy (eat predominantly aspen buds, catkins, twigs and leaves)
		Other foods include willow twigs, hazel catkins, rosehips, balsam poplar buds, Saskatoon & Canada buffalo-berries
		Aboriginal people observe adults picking up sand for their gizzards[116]
Shelter/Cover	Winter	In winter, adults burrow into snow to avoid predators
		Spruce for roosting at night, conifers are required for shelter
Reproduction	Spring	Males attract mates by drumming from one of a few selected fallen logs in their territory (kept for their lifetime)
		Prefer fallen poplar or conifers that are not visible to aerial predators (tall shrubs ideally present)
		May prefer young forests (< 30 y) with abundant shrubs (shrub canopy cover & height of 66 % and > 0.8 m)
	Spring & Summer	Nest on the ground near or under a fallen log or near the base of a tree
		Prefer sites in dense stands of older aspen (open understory) or willow that are close to forest openings
	Summer	Require forest openings for brood forage habitat; prefer small clearings (< 0.5 ha), clear-cuts or regenerating young aspen stands (< 10 y)
Movements	Fall	Juveniles prefer to disperse through contiguous aspen forest, but will use riparian corridors if aspen is fragmented

D.5.14 Pileated Woodpecker

Pileated woodpecker is the largest woodpecker in Canada and is widely distributed in interior and coastal forests. It plays a critical ecological role in forest ecosystems, because, as a large primary cavity excavator, it provides nesting habitat not just for itself but for numerous other bird and arboreal mammal species[117]. It also plays an important role in controlling insect populations, particularly the carpenter ant which is its preferred winter food[117].

Pileated woodpeckers will forage on trees of a variety of ages and species; however, nest excavation requires reasonably large diameter trees, and thus this species is frequently associated with mature to old growth forests. The forest types occupied by pileated woodpeckers during foraging or nesting correspond to upland ecosite phases b1-3 and d1-3, and riparian ecosite phases e2, f1 and f2[118].

Like other woodpeckers, this species is predominantly insectivorous and spends most of its time foraging on tree trunks. Where insects are abundant, an adult woodpecker pair will occupy and defend the same home range (~1,500 ha or 15 km^2 in northern boreal forests) year-round for several years[117]. Larger home ranges in northern parts of the continental range may reflect the overall smaller diameters of trees at greater latitudes. Finding trees suitable for excavating cavities is likely the key determinant for occupation of a forested area by pileated woodpecker.

Adult pairs typically excavate a new nesting cavity each year, leaving older sites as roosting holes or nesting habitat for other species. The preferred tree species in Alberta is trembling aspen (used ~90 % of the time), perhaps due to its susceptibility to fungal stem decay, which produces an internal decay column surrounded by living sapwood[117]. Forest stands used for nesting sites are often medium density stands, where average diameter and basal area of trees are relatively large, and cavity trees are surrounded by sufficient open space to allow adults and young to evade perched or aerial predators (owls, raptors). Nest sites are also always close to water, which may explain why many are found at lower elevations[117].

Seasonal changes in foraging do occur, but pileated woodpecker is likely more limited in winter by abundance of roosting sites rather than food supply. Roosting cavities are critical for thermal cover and predator evasion, and occur in standing trees with a hollow chamber. Roosting cavities are not used as nesting habitat, although they may be old, abandoned nests.

Table D.21 describes the relatively well known habitat needs of pileated woodpecker for food, cover, breeding, and/or travel. This species is an important component of old growth forest and mixedwood forest bird communities, and additional general information on habitat may be found in sections D.11 and D.12.

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[117] Westworth Associates 2002

[118] URSUS Ecosystem Management 2003

Table D. 21 Habitat requirements of pileated woodpecker [117]

Habit	Season	Habitat Requirements
Food	All	Eat mostly wood-boring insects, preferably carpenter ants in winter & beetles in spring; in summer will surface forage more on surface-dwelling insects, fruit & nuts
		Prefer stands with ≥ 6 dead, damaged or diseased trees per ha (600/km^2) with diameter at breast height (dbh) > 16 cm
		Prefer ≥ 7 downed logs per ha (700/km^2) with average diameter > 18 cm
		Prefer canopy closure > 5 %
	Summer	Use deciduous-dominated stands more & trees in a more advanced stage of decay
	Winter	May use coniferous-dominated stands more due to reduced snow accumulation; frequently use injured/dying white spruce
Shelter/Cover	All	Roosting cavities are used for thermal protection & escape from predators; are often old, abandoned nest cavities (see below for requirements); have multiple sites in territory
		Roosting cavities occur in hollow chambers where multiple entrances/ exits can be excavated (predator evasion)
		Prefer open understory surrounding cavities (fly space)
Reproduction	Spring & Summer	Excavate nest cavities in mature - old growth trees, usually in stands of similar age but sometimes in residual trees left in younger stands, 8 - 15 m above ground
		Prefer decaying trembling aspen, followed by balsam poplar, dead white spruce
		Prefer nest sites < 50 m from water & never more than 150 m
		Prefer > 5 % canopy closure, ≥ 14 m canopy height, > 20 % deciduous species, open understory
		Prefer > 20 deciduous trees or coniferous snags per ha with dbh > 30 cm (2000/km^2)
Movements	All	Exhibit strong site fidelity
	Summer	During chick-rearing, forage within 1 km of nest cavity

D.5.15 Boreal Owl

Boreal owl is a nocturnal, mid-size owl resident in the boreal forests of Alberta. Owls are a key predator group for forest bird and rodent communities, and the boreal owl fills this niche in a variety of mature and old growth forest types in the oil sands region. In addition, provided nesting habitat is available along boundaries, boreal owl may serve to control rodent damage to establishing vegetation on reclaimed landscapes.

Boreal owl preys predominantly on rodents, and may rely heavily on red-backed voles in parts of its range[119]. Hence, boreal owl hunts in forests and open areas where mice, voles and shrews are abundant and vulnerable to aerial capture (a limited understory). It nests in tree cavities, often those excavated by pileated woodpeckers and northern flickers[119], so it is also present in the mature forests where these species can find standing wood in a suitable state of decay. The forest types used by boreal owl for foraging, nesting and roosting correspond to upland ecosite phases b4 and d3, riparian ecosite phases e2, e3, f2 and f3, lowland ecosite phases g1 and h1, and wetland ecosite phases i1 and j2[120].

Like the white-winged crossbill (a priority species for old growth forest), boreal owl can be nomadic, particularly in areas where key prey species experience cyclic population changes[119]. That is likely the case in the oil sands region, where red-backed vole would be a common prey. Home range size varies widely across the continent, but could well be several thousand hectares. With little known about the magnitude of movements for boreal owl in northeastern Alberta (much of the research on the species has been conducted in Ontario), this species may best serve as an indicator of rodent prey abundance in reclaimed landscapes.

Male owls establish breeding territories and call in females to nest. In years when prey densities are low, a greater number of individuals choose not to initiate nest territory establishment than in years when prey is abundant[119]. Thus the density of nesting territories and reproductive success to fledge would provide valuable information on the rodent abundance in reclaimed landscapes. Boreal owl nesting habitat is often closely associated with the abundance of pileated woodpecker and their preferred excavation tree, aspen. However, boreal owl will use nest boxes[121], making them potentially less dependent on the establishment of woodpeckers in reclaimed environments.

Table D.22 describes the needs of boreal owl for food, cover, breeding, and/or travel. This species is an important component of old growth forest and mixedwood forest bird communities, and additional general information on habitat may be found in sections D.11, D.12, and D.14.

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[119] Westworth Associates 2002

[120] Westworth Associates 2002; URSUS Ecosystem Management 2003; Golder Associates 2007

[121] Hayward et al. 1992

Table D. 22 Habitat requirements of boreal owl [119]

Habit	Season	Habitat Requirements
Food	All	Prey mostly on small mammals: red-backed vole, heather/mountain vole, northern bog lemming, deer mouse, flying squirrel, chipmunks, shrews
		Rodent densities are high in balsam poplar, trembling aspen - white spruce & jack pine stands
	Spring	Forage habitat in region is often open fens and bogs surrounded by wooded area for roosting
	Winter	May prefer to hunt in coniferous and mixedwood stands due to reduced snow ground cover
Shelter/Cover	All	Roost during day & choose different sites every day
		Frequently roost in dense coniferous stands, ~5 m above ground, on branches close to trunk
		Prefer canopy cover ≥40 %, canopy height ≥12 m, and conifer composition ≥45 %
Reproduction	Spring & Summer	Nest in natural tree cavities, large woodpecker holes, nest boxes (secondary cavity nesters, do not excavate); 10 - 20 m above ground
		Prefer aspen, possibly because of preference by pileated woodpeckers
		Prefer mature - old growth mixedwood or coniferous forests, canopy height 11 - 17 m, open understory, multi-layered canopy
		Prefer stands with ≥20 deciduous trees or coniferous snags per ha with diameter at breast height ≥ 35 cm (2000/km^2)
		Prefer high density of trees, ≥200 trees per ha (20,000/km^2)
		Minimum patch size for nesting may be ~ 1 ha (0.01 km^2)
Movements	All	May be nomadic, especially when prey is scarce; nightly travel of 1-2 km

D.5.16 Canadian Toad

Canadian toad is a semi-aquatic amphibian listed as 'may be at risk' in Alberta[122]. Like beaver, it is a transition species, inhabiting both terrestrial and aquatic environments and requiring habitat elements in both to survive. Where locally abundant, it is likely prey for many species of semi-aquatic wildlife, despite the glandular secretions designed to make it unpalatable.

Canadian toad has a significant seasonal component to its habitat use, as it requires wetland or aquatic habitat to breed in the spring and terrestrial habitat to over-winter. Hibernacula sites may be located in upland ecosite phases a1, b1-4, c1 and d2-3. Foraging may occur in riparian and lowland ecosite phases e1-3 and g1[123]. Breeding may successfully occur wherever there is sufficient standing or slowly moving water to last the few months required for young to transform into toadlets.

Canadian toad in the oil sands region are living well into the northern half of their continental range. In cold, northern climates frogs and toads have two basic options to survive the winter: they can avoid subzero temperatures; or they can tolerate freezing. Many of the frogs in the oil sands region take the second option, using glucose as a cryo-protectant to control internal freezing and exclude ice crystals from within cells[124]. However, Canadian toads take the first option, burrowing below the frost line in sandy terrestrial soils where water does not accumulate (above the water table)[125]. In this way, they can survive in areas where winter temperatures dip to -30°C, even though their lethal minimum core temperature is probably similar to the western toad, -2°C[126]. Canadian toad require specific soil conditions to prevent freezing, and it is difficult to monitor how many toads die in sub-optimal hibernacula over the winter. Canadian toad can dig progressively deeper during the course of the winter, in response to lowering soil temperature cues[126].

Frogs and toads are not that selective about breeding waters, and often make poor choices where water dries up before tadpoles can metamorphose. Time to metamorphosis varies with water temperature (faster in warmer water), but typically is a couple of months; hence standing or slow-moving water must be shallow, preferably without fish, but of sufficient depth to withstand about two months of evaporation. Amphibians in general have small home ranges and Canadian toad likely will not routinely travel more than 1 km between over-wintering and breeding habitats.

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[122] Westworth Associates 2002

[123] Westworth Associates 2002; URSUS Ecosystem Management 2003; Golder Associates 2006a,b

[124] Pinder et al. 1992; Garibaldi Heritage and Environmental Consulting 2006a

[125] AXYS Environmental Consulting 2003

[126] Pinder et al. 1992

Table D. 23 Habitat requirements of Canadian toad [122]

Habit	Season	Habitat Requirements
Food	Spring to Fall	Eat invertebrates, mostly insects (grasshoppers, flies) & worms
		Forage mostly on land in wet meadows, wetland margins, riparian forests
Over-wintering	Winter	Over-winter in hibernacula in upland, well-drained soils
		Often located in aspen, jack pine stands
		Require sandy/coarse-grained fluvial or fine till soils with low salinity
		Need to be able to dig deeper than the frost line and remain above the water table; natural sites occur on south-facing 40° slopes at depths of 8 cm[125]
		May require sparse understory with few roots to impede digging
Reproduction	Spring	Breed in shallow (≤ 2 m) freshwater (low salinity), usually stagnant, in wetlands, lakes or ephemeral pools, close to shore
		Prefer water close to hibernacula, < 500 m
		Prefer sites with emergent/submergent vegetation for cover & egg mass attachment
Early Development	Summer	Tadpoles graze on algae, detritus, submergent vegetation
		More successful in water with little to no current (low stamina swimmers), no fish predators, good vegetative cover
Movements	Spring & Fall	Mass movements to & from hibernacula, breeding ponds are triggered by temperature changes and usually occur during heavy rains

D.6 Guidelines for Monitoring Habitat Suitability & Wildlife Use of Reclaimed Land

D.6.1 Background

There is currently an underlying uncertainty regarding the potential use of oil sands reclaimed landscapes by boreal wildlife species. This is largely a result of a limited amount of reclaimed landscapes and limited requirements to undertake monitoring of wildlife use of these reclaimed habitats. A summary of some of the monitoring of wildlife use of reclaimed landscapes that has been conducted within Suncor's main plant area (Lease 86/17) is provided below.

D.6.1.1 Summary of Wildlife Use of Reclaimed Landscapes – Suncor's Lease 86/17 (Golder 2004 and 2009)

Suncor Energy has been monitoring wildlife use of reclaimed landscapes on Lease 86/17 since 1997. The main focus has been on mammal use of reclaimed landscapes and comparing use in these habitats to use in natural areas along the Athabasca River, primarily through winter track counts. Since this time, the reclamation monitoring program has included a wide array of field programs to determine the existing wildlife community using the reclaimed landscapes. The surveys and target groups are as follows:

- Cursory vegetation inventory and site-specific classification based on dominant canopy and shrub species;
- Winter track counts – winter resident mammals including large carnivores, meso-carnivores, small mammals and ungulates;
- Browse-pellet surveys for ungulates;
- Small mammal surveys for voles and mice;
- Non-invasive DNA surveys using hair snagging methods for carnivore species, in particular wolverine;
- Remote camera programs for all wildlife species, particularly mammals;
- Waterfowl and waterbird visual surveys;
- Breeding songbird point counts for passerines and other bird species;
- Raptor surveys for diurnal hawks and owls;
- Amphibian breeding call surveys for frogs and toads; and
- Canadian toad telemetry study.

Plant Communities

The reclaimed habitat types that exist on Lease 86/17 range from sparsely treed areas with open graminoid-covered understory (e.g., Tar Island dyke) on reclamation-mixed soils (e.g., sand and peat mix) to areas with dense tree and shrub cover (e.g., Reclamation Area 8) on overburden materials. Most deciduous tree species consist of white birch, trembling aspen, balsam poplar and Manitoba maple with some willow species reaching tree height. Most conifer tree species consist of white spruce, jack pine, lodgepole pine and black spruce. Shrub species primarily include willow species, wild rose and wild red raspberry.

A summary of wildlife recorded on Lease 86/17 is provided below, by species groups.

Mammals

In total, fourteen winter track count surveys have been conducted since 1997 to determine the presence of winter-resident mammals. Winter-resident mammal species observed on reclaimed landscapes include red squirrel, deer species (both white-tailed and mule), moose, red fox, coyote, wolf, Canada lynx, weasel species (least weasel and ermine), fisher or marten, river otter and wolverine. Although the species present on reclaimed landscapes are quite similar to natural boreal forest conditions, the abundance of species is markedly different. Based on all tracking data collected, deer and coyote track counts are significantly higher on reclaimed landscapes than in adjacent natural forest. Typical boreal species such as moose, fisher or marten and Canada lynx are much more abundant in natural forests.

No meaningful trends could be determined from the browse-pellet information; however, deer pellets were consistently observed on reclaimed landscapes and there were very few observations of ungulate browse on reclaimed landscapes. Browse-pellet surveys were only completed once, and then were deleted from the program as considerable effort is required to determine any ecologically-meaningful trends.

Small mammal surveys for voles and mice (e.g., Cricetids) have been conducted for two main purposes: 1) to determine small mammal species composition on reclaimed landscapes compared to natural forest; and 2) to determine the species composition and abundance of small mammals on reclaimed landscapes with and without coarse woody debris applications. During both programs, deer mice were the most commonly observed species, accounting for more than 90% of the captures during the composition and abundance inventories and accounting for all of the observations during the coarse woody debris surveys. The other small mammal species captured during the composition and abundance inventory were meadow voles (6) and red-backed voles (1). Deer mice observations were consistently higher in reclaimed areas with coarse woody debris applications.

In 2003 and 2004, a wolverine was sporadically observed for a short period of time within and around Suncor's operations. A hair snagging study was initiated in the winter of 2004 - 2005 to try and capture hair samples for DNA analysis to identify the number of individuals and sex of any wolverine in the area. Sampling locations consisted of trees wrapped in barbed wire and paired with remote cameras. The program was unsuccessful at capturing any wolverine hair or wolverine observations. However, the program did record fisher, marten, coyote, wolf, moose and white-tailed deer through photo documentation.

Remote camera programs were initiated to look at wildlife use along the Athabasca and Steepbank River valleys and escarpments, and were not intended to determine wildlife use of reclaimed landscapes specifically. There was a focus to investigate the use of the Athabasca River valley, particularly on the east side, north and south of Suncor's operations to gather evidence on movement barriers. Photographic monitoring commenced in 2004 with an emphasis on the east side of the Suncor Bridge, which connects the main plant operations, west of the river, with the Steepbank and Millenium operations on the east side. White-tailed deer, black bear, coyotes, red fox and grey wolf have all been regularly observed along the monitored areas of the Athabasca River. However, moose were not a regular observation and were observed much more frequently on the Steepbank River.

Waterbirds and Waterfowl

The monitoring of waterbirds and waterfowl in reclaimed wetlands within Suncor's Lease 86/17 has been limited; however, some data has been collected with particular emphasis on Crane Lake. A formal survey of wetlands on Lease 86/17 was completed in 2007. The most abundant waterfowl species observed were lesser scaup and canvasback, with American coots being the most commonly observed waterbird species. Crane Lake, which is a reclaimed overburden dump area, contained the most waterfowl species and most waterbird species.

Raptors

Owl surveys were conducted in March 1999 along the Athabasca and Steepbank Rivers. The boreal owl is the most common owl heard near Lease 86/17, with the great gray owl and barred owl being much less common. The great-horned owl has been incidentally observed in Lease 86/17.

Raptor observations were compiled from a series of reports produced for Suncor between 1976 and 1983. Common raptors of the reclaimed landscapes include American kestrel and northern harrier, with sharp-shinned hawks being less common. Common migrants include the rough-legged hawk.

With the exception of the American kestrel, there is limited use of reclaimed landscapes by owls and hawks. However, it is more than likely that the early successional status of reclaimed landscapes, and subsequently their openness, makes these areas ideal hunting areas for owls and hawks.

Songbirds

Bedding bird point count surveys have been conducted to identify the species presence, relative abundance, habitat use and overall community composition of songbirds within and around Lease 86/17 since 2002. The objective of this program has been to compare the species present and composition of songbird communities on reclaimed landscapes with natural forest of different ages. Four surveys have been completed as follows: 2002, 2003 and two surveys in 2008. When all of the data across years was pooled, and year was accounted for as a covariate, there were no significant differences in the number of species (e.g., species richness), species diversity or bird abundance between natural and reclaimed landscapes. However, there was a strong trend for the natural areas to be higher in all of these categories. There is an overall trend of a bird community that prefers young seral habitats, with the most common species being white-throated sparrow, chipping sparrow, Tennessee warbler, clay-coloured sparrow, and song sparrow.

Amphibians

Amphibian breeding call surveys have been conducted in Lease 86/17, including constructed wetlands, from 2000 through 2006. A telemetry program for Canadian toads was initiated in 2005 and carried out through 2006. The focus of this study was to follow toad movements throughout the summer until they enter their over-wintering hibernacula. The following species have been found to use the majority of existing natural and constructed wetlands within 86/17: wood frog, boreal chorus frog and Canadian toad. Reclaimed landforms in the oil sands region appear to provide ideal habitat for Canadian toads, with steep slopes comprised of loose sand material, which make ideal hibernacula, located adjacent to waterbodies for breeding. Wood frogs and boreal chorus frogs also appear to thrive in these areas.

Species of Concern

Wildlife species of concern include those species that are listed provincially as 'Sensitive', 'May be at Risk' or 'At Risk' (ASRD 2006) and/or those species that are listed federally as 'Special Concern', 'Threatened' or 'Endangered' (COSEWIC 2009). Mammalian species of concern observed during monitoring programs on Suncor's reclaimed landscapes in Lease 86/17 include the wolverine ('May be at Risk' and 'Special Concern') and fisher ('Sensitive'). Waterfowl and waterbird species that have been observed within and adjacent to reclaimed habitats include lesser scaup ('Sensitive'), horned grebe ('Sensitive'), sora ('Sensitive'), great blue heron ('Sensitive'), sandhill crane ('Sensitive') and black tern ('Sensitive'). Raptor species of concern that have been observed include the osprey ('Sensitive'), bald eagle ('Sensitive'), northern harrier ('Sensitive'), northern hawk owl ('Sensitive), barred owl ('Sensitive'), northern pygmy owl ('Sensitive') and great gray owl ('Sensitive'). Songbird species observed in reclaimed habitats include the common yellowthroat ('Sensitive') and least flycatcher ('Sensitive'). Other bird species of concern observed in natural habitats adjacent to reclaimed habitats include sharp-tailed grouse ('Sensitive'), common nighthawk ('Sensitive' and 'Threatened'), pileated woodpecker ('Sensitive'), black-throated green warbler ('Sensitive'), Canada warbler ('Sensitive' and 'Threatened') and western tanager ('Sensitive'). The Canadian toad ('May be at Risk') is the only amphibian species of concern observed in reclaimed habitats.

D.6.2 Context

Land reclaimed for wildlife habitat will be subject to a certification process, which will evaluate whether equivalent land capability, for example, has been achieved. That evaluation process will likely rely heavily on data derived from monitoring programs. In instances where the identified target end land use was wildlife habitat, there may be two key means of monitoring achievement:

1. The derivation of habitat suitability indices, based on the presence of structural and functional elements in the landscape; and
2. The monitoring of actual use by wildlife priority species.

CEMA conducted a mapping exercise in 2003 that classified existing habitat in the oil sands region. As part of this work, qualitative HSIs were derived for priority species, using a consensus-based approach and input from traditional and western science knowledge sources. Similarly, the first edition of this guideline included HSIs derived for the Syncrude Aurora mine site, and the current edition includes HSIs derived for the Suncor Voyageur mine site (See Section D.10, Table D.27). These were quantitative (using a numeric scale from 0 to 1) and developed using wildlife monitoring data from the region where possible. These indices may also be used to evaluate the establishment of wildlife habitat on reclaimed land by monitoring the development of key habitat elements (availability of woody browse preferred by moose for instance). As discussed in Section D.2, HSIs model the capacity of a mapped natural area to support a wildlife species of interest; their accuracy is dependent on the quality of input data. Hence, in the oil sands region where wildlife monitoring has historically been infrequent and inconsistent, there is no mechanism for validating the suitability values derived, and caution must be used when interpreting them. As well-designed, long-term and consistent monitoring programs are implemented in the region and model equations are refined to reflect local conditions in the boreal forest, the accuracy of HSI models for wildlife will increase.

Monitoring of actual use by wildlife priority species will require a well-designed field program, with monitoring parameters chosen to reflect local conditions in the reclaimed environment as much as possible. Presence or absence is the simplest measure of use to collect, but provides limited information on the quality of key survival and reproduction determinants in the landscape.

Suggestions for wildlife monitoring program parameters are listed in Table D.24. General advice on monitoring program design is given in the revised wetlands manual[127]. Incorporating both wildlife use monitoring and habitat suitability indexing into a wildlife evaluation program may provide the greatest interpretive capacity. Where monitoring indicates a lack of wildlife use of apparently suitable habitat, the examination for cause (barriers to immigration) can be pursued with greater confidence.

The Alberta Biodiversity Monitoring Institute has developed a province-wide biodiversity monitoring program that may be adapted for the long-term verification monitoring of habitat on reclaimed landscapes in the oil sands region. However, that program places its emphasis on ecosystem health and monitors broad community variables such as species diversity and composition rather than population trends in select priority species of wildlife. Where the population establishment of priority species on reclaimed land is of interest, other species-specific monitoring programs must be developed.

Site-specific monitoring programs, required as part of the EPEA approvals, vary between oil sands mining operations and in situ operations. Typical wildlife-related monitoring conditions for oil sands mining operations are related to wildlife movement, river buffers and setbacks, and habitat effectiveness and connectivity. These programs are currently being addressed through a collaborative research program within the Integrated Landscape Management (ILM) group at the University of Alberta and funded through the Canadian Oil Sands Network for Research and Development (CONRAD). Typical wildlife-related programs for in situ operations include monitoring species of concern, mitigation monitoring and monitoring wildlife use of reclaimed areas.

These monitoring programs may include any of the following survey protocols:

- Remote camera surveys,
- Waterfowl surveys,
- Amphibian call surveys,
- Winter track counts,
- Owl surveys,
- Bat surveys,
- Track counts,
- Small mammal monitoring,
- Browse pellet surveys, and
- Breeding bird suveys.

Suggested monitoring techniques based on the discussions of regional wildlife experts during the BWSG January 2008 workshop are summarized in Table D.24. The development of a detailed monitoring program will need to have a well-designed study that ensures that spatial and temporal scales are addressed and includes the identification of appropriate monitoring parameters and well-suited survey techniques. The integration of site specific monitoring data to provide information on regional wildlife is recommended to provide information for coordinated closure planning.

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[127] Alberta Environment 2007

Table D. 24 Potential monitoring parameters for evaluating the use of reclaimed landscapes by wildlife priority species

Species	Potential Monitoring Parameters	Monitoring Technique[128]
Moose	Track or individual density of adults	Telemetry (GPS/Radio) programs; aerial surveys for density and/or calf survival; winter track counts;
Woodland caribou	Range extensions or contractions around management zones[129]; telemetry studies; calf survival rates[130]	Telemetry (GPS/Radio) programs; winter survey track counts; aerial surveys; remote camera stations
Beaver	Density/presence of active lodges	Aerial monitoring surveys in fall for food caches and active lodges
Muskrat	Density/presence of push-ups	Aerial monitoring surveys in fall for feeding platforms and push-ups
Red-backed vole	Density from live-trapping [131]	Live trapping and/or ear tagging to determine population densities
Snowshoe hare	Population density[132] & cycle length	Permanent pellet sample plots; winter survey track counts
Black bear	Presence/Absence; population density; scat analysis[133]	Remote camera stations; telemetry (GPS/radio) programs; DNA hair snagging
Lynx	Presence/Absence; population density; track counts	Winter track surveys; remote camera stations; DNA hair trapping
Fisher	Presence/Absence; population density; track counts	Remote camera stations; DNA hair trapping; winter track surveys
River otter	Presence/Absence; population density; track counts	Remote camera stations; DNA hair trapping; winter track surveys
Old growth birds	Species presence and composition; reproductive rates (fledge success)	Point counts; territory mapping; nest searching
Mixed wood birds	Species presence and composition; reproductive rates (fledge success)	Point counts; territory mapping; nest searching
Ruffed grouse	Density of male territories/drumming activity[134]	Targeted sampling (e.g., drumming sampling in early spring)
Pileated woodpecker	Abundance of abandoned and occupied nesting cavities	Early morning call surveys; habitat use surveys of feeding signs; breeding activity using nest cavity searches
Boreal owl	Nest box occupancy[135]	Call back (e.g., single species technique approach)[136]
Canadian toad	Development of hibernacula; juvenile dispersal patterns; survival to metamorphosis	May and June call survey

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[128] based on recommendations compiled during the BWSG January 2008 Wildlife Expert Workshop

[129] Caribou monitoring is currently conducted by the research sub-committee of the Alberta Caribou Committee

[130] Stuart-Smith et al. 1997; Gustine et al. 2006

[131] may be estimated by live-trapping for rodents (Pearce and Venier 2005) or ink-pad track counts (Nams and Gillis 2003; Wiewel et al. 2007)

[132] may be estimated using pellet counts (Mills et al. 2005)

[133] Holcroft and Herrero 1991; Kendall et al. 1992; Wasser et al. 2004

[134] Rodgers 1981

[135] Hayward et al. 1992; Moller 1994

[136] Takats et al 2001

The BWSG January 2008 Wildlife Expert Workshop identified additional species that could be monitored in newly reclaimed sites based on the premise that these species could be considered early successional species. Research is required to further develop the concept of monitoring for early successional species on reclaimed landscapes. Potential species to monitor are listed below:

- Alder flycatcher
- Yellow warbler
- Philadelphia vireo
- Boreal chickadee
- Gray jay
- Swanson's thrush
- Warbling vireo

D.7 Addressing Uncertainty through Research & Development

Reclamation practices and techniques in the oil sands region are constantly evolving in response to ongoing monitoring and research. However, monitoring and research also identify new issues or data gaps that should be addressed. These data gaps include but are not limited to a better understanding of hydrogeological dynamics and processes, soil and process water chemistry (e.g., salts, hydrocarbons), climate change, and other ecological processes. This section identifies some sources of uncertainty and, should they arise, some mechanisms that may allow for adaptive management. Also included are recommendations for research initiatives that address knowledge gaps related to these uncertainties.

D.7.1 Soil and Water Chemistry

The increased presence of salts, air-borne acids, metals and organic chemicals in soils and surface water on reclaimed landscapes may have a finite time-frame, but nonetheless has the potential to affect wildlife for many years. There is a considerable level of uncertainty about how these compounds will affect the following:

- Palatability and digestibility of browse for herbivores;
- Soil licks on reclaimed landscapes;
- Canadian toad adults in hibernacula soils and larvae in wetland waters;
- Establishment and growth rates for vegetation communities;
- Bioaccumulation of contaminants and associated toxicity in wildlife food chains; and
- Tissue burdens of metals and organic chemicals in country foods.

These sources of uncertainty may be addressed by an ongoing monitoring program. Tissues and non-destructive sampling of scat, feathers or fur will identify geographic variation in levels of contaminants.

Ongoing research continues to investigate the species-specific tolerance levels of various native plants to salts and acids[137]. Research elsewhere indicates that changes in air temperature, and atmospheric concentrations of carbon dioxide and nitrogen influence the levels of phenolics and terpenoids in birch bark, which in turn alters the tree's resistance or palatability to browsing by hares[138]. Herbivores such as moose and snowshoe hare may benefit from the increased content of some minerals (sodium, magnesium) in overburden soils used as lick sites[139]. However, amphibians found in the oil sands region are very poor osmoregulators and may be adversely impacted by elevated salts in hibernacula soils and in waters used for breeding or over-wintering[140]. Further revisions to this guideline should attempt to summarize the state-of-knowledge on potential contaminant effects on wildlife.

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[137] Renault et al. 1999; Vitt et al. 2003

[138] Pastor and Naiman 1992; Mattson et al. 2004

[139] Faber et al. 1993, Ayotte et al. 2006

[140] Dole et al. 1985; Shoemaker et al. 1992; Jørgensen 1997; Gomez-Mestre et al. 2004

D.7.2 Monitoring Data and Accuracy of Habitat Models

The short-comings of existing HSIs were described in Sections D.2 and D.5. The accuracy limitations on habitat models like the HSI applied to the oil sands region are fundamentally related to the level of 'ground-truthing' conducted for vegetation mapping and wildlife use[141]. The predictive capacity of habitat models is currently severely limited by the volume of empirical regional data on distribution and mapping of ecosite phases and seasonal use of ecosite phases by wildlife populations. Extensive monitoring is required to improve model accuracy.

D.7.3 Gaps in Regional Knowledge of Wildlife Populations

The pre-disturbance focus and localized study areas of wildlife surveys undertaken in the region, combined with the physical differences in reclaimed and undisturbed boreal environments leads to uncertainty with respect to the basic life history characterizations of priority species. An evaluation of the long-term effects of anthropogenic disturbance of priority species in the oil sands region requires a thorough understanding of their life history. Gaps in regional knowledge were identified in the species accounts of Section D.5 and are summarized here in Table D.25.

Table D. 25 Gaps in regional knowledge of habitat requirements for priority species in reclaimed landscapes.

Species	Knowledge Gap
All	Comprehensive regional population trend data, including dispersal and immigration patterns
Boreal owl Mixed wood forest birds Old-growth forest birds	Regional productivity rates for undisturbed settings
Fisher Mixed wood forest birds Red-backed vole	Identification of key habitat variables that limit the occupation of young reclaimed forest stands, and derivation of design enhancements that promote use
Black bear Mixed wood forest birds Ruffed grouse Snowshoe hare	Size of forest gap or clearing that restricts movements of individuals between forest patches
Lynx Moose Woodland caribou	Reclamation of bogs and fens
Beaver Moose Muskrat Snowshoe hare	Palatability of vegetation on reclaimed land, where salts, metals and acids may be elevated above regional averages
Moose Snowshoe hare	Chemical composition and design of mineral and salt soil licks
Canadian toad	Threshold concentrations of water and soil salts for survival of larvae and over-wintering adults

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[141] Golder Associates 2006; URSUS Ecosystem Management 2006

D.7.4 Ecological Interactions and Natural Disturbance

As wildlife colonize and use reclaimed landscapes, they will affect the dynamics of the ecosystem. Herbivores and predators interact in complex ways. Design teams may expect the occurrence of some of these interactions, without being able to anticipate their end result. It may be prudent to develop a defined step-wise decision-making process that drives the managed intervention or lack thereof in circumstances related to:

- Beaver dam construction and subsequent flooding of upland terrain;
- Grazing damage to establishing vegetation by rodents, muskrats, hare, moose;
- Predation on young of newly established prey populations (wolves on moose, caribou calves for instance); or
- Predation on ecological keystone species, such as pileated woodpecker or snowshoe hare, at levels that are potentially unsustainable.

D.7.5 Will Reclamation Be Sustainable Over Time

Related to both climate change and wildlife interactions is the decision-making required to address sporadic natural disturbances, such as forest fires, wind or ice storms, and forest insect infestations. These events drive ecological dynamics at some level in natural boreal ecosystems. They have the potential to produce devastating or beneficial effects in reclaimed landscapes. In this case, there is a considerable general knowledge about what impacts these events render on wildlife. However, there has been no consultative process within local communities regarding how to proceed if fire, weather or insects threaten to undo reclamation efforts in reclaimed landscapes.

D.7.6 Coordination Of Wildlife Management Efforts

Reclamation to meet the end land use objective of re-establishing wildlife habitat on reclaimed landscapes for priority species with large territories or species that use multiple habitat types will require coordination of wildlife management efforts. The procedures for addressing coordinated planning across lease boundaries are not well-defined. Some suggestions for implementing cross-boundary planning could include the following:

- Evaluating landscape patterning to determine relative proportions of terrestrial (upland, lowland and riparian) and aquatic (wetlands, lakes and streams) habitats;
- Establishing strategic set asides of habitat refugia based on TEK;
- Establishing inter-mine coordination of reclamation materials (e.g., coarse woody debris, LFH amendment); or
- Monitoring wildlife at a regional scale.

References

Annotated Bibliography of Principle Review Documents

AXYS Environmental Consulting Ltd. 2003. Literature review of reclamation techniques for wildlife habitats in the boreal forest. Prepared for the Cumulative Environmental Management Association (CEMA), Biodiversity and Wildlife Subgroup of the Reclamation Working Group. February/03.

Summary: This report documents the habitat requirements for CEMA priority 1 species, the sources of landscape level disturbances in the oil sands region and techniques with potential application to reclamation of wildlife habitat. Habitat requirements are identified at landscape, stand and element levels for caribou, moose, fisher, red-backed vole, snowshoe hare, lynx, old growth forest birds, muskrat and Canadian toad. Priority 2 species described in this appendix are not included. The main effects of oil sands mining, forestry, SAGD and linear disturbances on wildlife are described. Broad reclamation techniques using upland forest patterning, fire, connectivity, lowland peatlands and understory structure are discussed, along with species-specific reclamation guidelines. Guidance on vegetation reclamation (including lichens) and ectomycorrhizal fungi inoculation are also provided.

Garibaldi Heritage and Environmental Consulting. 2006a. Report on TEK input into wildlife habitat reclamation recommendations. Prepared for the Cumulative Environmental Management Association (CEMA), Biodiversity and Wildlife Subgroup of the Reclamation Working Group. August/06.

Summary: This report documents the results of a region-wide consultation process to gather Aboriginal community input into wildlife habitat reclamation requirements. In particular, it describes the life history and ranges of priority species of wildlife prior to oil sands development in the region compared to present day. It also, describes key limiting variables to reclamation and recommends mechanisms to overcome those variables for each species. Repeated themes throughout relate to the interconnectedness of all species and their habitat, and the sensitivity to disturbance exhibited by many of the priority species.

URSUS Ecosystem Management Ltd. 2003. Regional habitat evaluation and mapping for key wildlife species in the Athabasca oil sands region. Prepared for the Cumulative Environmental Management Association (CEMA), Wildlife and Fish Working Group. August/03.

Summary: This report used existing vegetation cover information catalogued in the Alberta Vegetation Inventory (AVI), phase 3 forest mapping, and the Alberta Ground Cover Classification (AGCC) to classify and map aerial extent of forest vegetation in a CEMA Priority 1 study area. Vegetation communities were described using dominant canopy species, by age categories (young, mature and old), by upland, riparian, lowland or wetland form, and by ecosite phase. Mapped and classified areas were then given a habitat suitability rating for priority species, using a qualitative scale ('very low' to 'very high') applied with a consensus-based evaluation during a workshop of habitat experts (regional biologists and Aboriginal people). In the process of ground-truthing the vegetation cover databases, issues arose with the accuracy of the AGCC data (found to be accurate only 45 % of the time); therefore, the URSUS report was revised and re-issued in 2006 (Kansas JL and Collister DM 2006. Wildlife habitat mapping SEWG (South) study area. Final report prepared for CEMA, Edmonton, AB. September/06). It used more precise data from smaller geographic areas. The information relating HSIs to ecosite phase descriptors was dropped; however, Section 5 has retained the information given in the 2003 report, with an appropriate cautionary tone, because of the general lack of alternative data on HSIs for the priority species in the region.

Westworth Associates Ltd. 2002. A review and assessment of existing information for key wildlife and fish species in the Regional Sustainable Development Strategy study area. Volume 1 – wildlife. Prepared for the Cumulative Environmental Management Association (CEMA), Wildlife and Fish Working Group. April/02.

Summary: This report provides detailed species accounts for CEMA wildlife priority species and community assemblages in the RSDS study area of northeastern Alberta. Information on life history, habitat requirements, regional distribution and population characteristics is given for Priority 1 and 2 wildlife (e.g., all wildlife described in Section 5 of this document). Habitats are described for foraging, reproducing, security / thermal cover and migration/movement requirements and the key characteristics of moderate to highly suitable habitat are tabulated. Information gaps are also identified.

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D.8 Glossary

Canopy - the tallest vegetation layer within a plant community, most often consisting of trees; also called the overstory.

Diameter at breast height (dbh) - diameter of a tree measured at 1.3 to 1.5 m above the ground surface.

Duff - the layer of partially and fully decomposed organic materials lying below the litter and immediately above the mineral soil.

Ecosite - ecological units that develop under similar environmental influences (climate, moisture and nutrient regime). Ecosites are groups of one or more ecosite phases that occur within the same portion of the edatope (e.g., lichen ecosite). Ecosite, in this classification system, is a functional unit defined by moisture and nutrient regime. It is not tied to specific landforms or plant communities as in other systems, but is based on the combined interaction of biophysical factors that together dictate the availability of moisture and nutrients for plant growth. Thus, ecosites are different in their moisture regime and/or nutrient regime[142].

Ecosite phase - a subdivision of the ecosite based on the dominant tree species in the canopy. On some sites where a tree canopy is lacking, the tallest structural vegetation layer determines the ecosite phase (e.g., shrubby and gramminoid phases). Some variation in humus form or plant species abundance may be observed between ecosite phases[142].

Ecosystem - a system of living organisms interacting with each other and their environment, linked together by energy flows and material cycling.

Ectomycorrhizal fungi - a group of fungi that form a mutually beneficial symbiotic association with roots of trees and shrubs, particularly those in temperate regions; the fungus surrounds but does not penetrate living cells in the roots; extensive mycelium extend far out into the soil and play an important role in transferring nutrients to the plant[143].

Edatope - moisture/nutrient grid that displays the potential ranges of relative moisture (very dry to wet) and nutrient (very poor to very rich) conditions and outlines relationships between each of the ecosites.

Emergent wetland vegetation - plant species that have a part extending below the normal water level in wetlands; plants adapted to periodic flooding, including sedges, reeds and cattails.

Forb - an herbaceous (vascular) plant which is not a grass, sedge or rush.

Generalist (habitat) - wildlife species that can survive and reproduce in a variety of habitat types (e.g., moose).

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[142] Beckingham and Archibald 1996

[143] Raven et al. 1981

Habitat suitability index (HSI) - mathematical models that estimate the value of habitat for wildlife species by relating a species' need for food and cover to structural and spatial attributes of vegetation types within a defined area. The HSI refers to the quality or suitability for a species or species group, and ranges in value from 1.0 (optimal/very high) to 0.0 (no value); there are a number of variations on the model equation, including qualitative derivation methods.

Hydric - a soil moisture regime used to describe sites where the water table is at or above the soil surface all year.

Hygric - a soil moisture regime used to describe sites where water is removed slowly enough to keep the soil wet for most of the growing season.

Hypogeous fungi - describes the form/functional niche of fungi that grow below ground; includes the ectomycorrhizal species; see Ectomycorrhizal fungi.

Lowland - terrain at topographical lows on the regional landscape.

Mesic - a soil moisture regime used to describe sites where water is removed somewhat slowly in relation to supply and where soil may remain moist for significant but sometimes short periods of the growing season.

Monitoring - measurements taken over space or time for the purpose of characterizing and assessing environmental conditions.

Passerines - a group of perching birds belonging to the taxonomic order Passeriformes.

Refugia - a stand of undisturbed natural vegetation retained within a mine development area that serves as a source of native species for re-colonization.

Riparian margin - terrain, vegetation or a position adjacent to or associated with a stream, flood plain, lake or wetland.

Salinity - a measure of the amount of salts in soil or water.

Seral - a stage in natural forest succession (e.g., early, mature); see Succession.

Shrub - a perennial woody-stemmed plant of relatively low stature, typically with several stems arising from or near the ground[143].

Sodicity - a measure of the amount of sodium in soil or water.

Snag - any standing dead or partially dead tree.

Specialist (habitat) - wildlife species that is dependent on a few habitat types for survival and reproduction (e.g., Cape May warbler).

Stand - a collection of plants having a relatively uniform composition and structure, and age in the case of forests.

Submergent wetland vegetation - plant species that have no part extending above the normal wetland water level, but which are rooted in a substrate (not floating).

Succession - the slow, orderly progression of changes in community composition during development of vegetation in any area, from initial colonization to the attainment of the climax typical of a particular geographic area.

Tree - a perennial woody plant generally with a single stem (trunk) and growing higher than 5 m[143].

Understory - the lower vegetation layers within a plant community, commonly shrub, grass or moss layers; see Canopy.

Upland - terrain situated at topographical highs on the regional landscape and not associated with streams, wetlands or lakes (e.g., riparian); see Lowland and Riparian margin.

Wetland - land having the water table at, near or above the land surface, or which is saturated for long enough periods to promote wetland or aquatic processes as indicated by hydric soils, hydrophytic vegetation, and various kinds of biological activity that are adapted to the wet environment; the Canadian Wetlands Classification System identifies five classes of wetlands, namely bogs, fens, marshes, shallow waters (or ponds) and swamps[144].

Woody debris - fallen, dead woody plant material in the process of decay on the forest floor.

Xeric - a soil moisture regime used to describe sites where water is removed very rapidly in relation to supply and soil is moist only for brief periods following precipitation.

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[144] National Wetlands Working Group 1997

D.9 Supporting Tables

Table D. 26 Palatability of plant species for key wildlife priority species based upon defined community types[145].

Plant	General palatability[146]	General tolerance[146]	Black bear		Moose		Red-backed vole		Ruffed grouse		Snowshoe hare
			Food use[147]	% frequency[148]	Food use[149]	% weight[150]	Food use[151]	Mean consumption[152]	Food use[147]	% volume[153]	Food use[147]
Balsam fir					2-3	16.9			3-4		m
Green alder	Med	Med			1-3, *				+		1, m
River alder	Med	Med			2-3, *				3-4		3-4, m
Saskatoon	Med	Med	1	T	1, *	0.9			2	5, 2.5	1
Bearberry	Med	Med		38			*				
White birch	Med	Med	3-4		2-3, *				1-2	-, 9.2	2, m
Dogwood	Med-high	High	+		1-2, *	25.3			1-2+	-, 1.6	
Beaked hazelnut					1, *	0.8	*		1-3	4, 1.4	2, m
Labrador tea					1, *	0.04					
Twin-flower					*						
Bracted honeysuckle				T	*						U
White spruce	High	Low			*			0.2	1-2		3, m
Black spruce					*					-, t	m
Balsam poplar	Med-high	High		5	2, *	6.9				1, -	m
Aspen	Med-high	Med-high			3, *	7.5	*		3-4	35, -	2-3, m
Pin cherry			1-4		1+, *				1-2	-, 10.6	+
Choke cherry	Med	Med	1-4		1+, *	0.1	*	3.1	1-2		+
Currant				24.4	*						
Prickly rose	High	Med		18.5	*	0.03	*		1+	5, -	
Raspberry	Low-med	Med	m	28	-, *	0.04	*		1-2+	-, 8.8	m
Willows	High	High		8.5	2-3, *	22.6			1-2	31, -	2-3, m

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[145] modified from table J.1 of the original revegetation manual (Oil Sands Vegetation Reclamation Committee 1998)

[146] Hardy BBT Limited 1989

[147] Martin et al. 1951; '-', use to an indeterminate extent; '+', 0.5-2% of diet; '1', 2-5% of diet; '2', 5-10% of diet; '3', 10-25% of diet; '4', 25-50% of diet; '5', >50% of diet; multiple values reflect regional variations in species usage; Chapman and Feldhamer 1982; 'm', major food source; 'u', unpalatable

[148] Holcroft and Herrero 1991

[149] Martin et al. 1951; Stelfox 1993; '*', common forages

[150] Zach and Mayoh 1982

[151] Martin et al. 1951; Green 1979; '*', common forages

[152] Vickery 1979

[153] Doerr 1973; Bump et al. 1947; '*', includes volumetric percentages to genus level; 't', trace

Plant	General palatability[146]	General tolerance[146]	Black bear		Moose		Red-backed vole		Ruffed grouse		Snowshoe hare
			Food use[147]	% frequency[148]	Food use[149]	% weight[150]	Food use[151]	Mean consumption[152]	Food use[147]	% volume[153]	Food use[147]
Canada	Low	Med-high	1	40	*		*			2, -	
Snowberry									2		1, u
Blueberry			3-4, m	43					1-2+		3
Bog cranberry			+, m	43	+		-, *		1		-
Low-bush cranberry					2-3, *				1-2	-, 2	3
Forb Layer			m								m
Showy aster				3					+		
Lady fern									1		2
Bunchberry								2.4			
Shield fern									+	-, 1.2	2
Fireweed	Med	Low		3.5	1						
Common horsetail			+	50	2, *						
Meadow horsetail			+	50	2, *						
Scouring rush			+	50	2, *						
Woodland horsetail			+		2, *						
Oak fern											2
Cream-coloured vetchling	Med	Low		73	*				+		
Wild lily-of-the valley								3.0	+		1
Common pink wintergreen									+		
Dewberry				22					1-2		
Grass Layer			m	89.3							m
Marsh reed-grass	Low-med	Low									
Sedge	Med	Med	+		2, *				2	-, 2.3	m
Hairy wild rye	Low-med	Med									

Table D. 27 **Habitat suitability indices (HSIs) for wildlife priority species using the ecosite phases and plant community types within the Suncor Voyageur mine area[154].**

Plant Community	Ecosite Phase	Black bear	Boreal owl	Canadian toad	Fisher	Lynx	Moose
Terrestrial systems							
Blueberry jack pine - aspen	b1	0.65	0.03	0.55	0.67	0.00	**0.23**
Blueberry aspen - white birch	b2	0.61	0.04	0.60	0.66	0.00	**0.18**
Blueberry aspen - white spruce	b3	0.62	0.38	0.53	0.80	0.00	**0.23**
Blueberry white spruce - jack pine	b4	0.49	0.10	0.55	0.70	0.00	**0.22**
Black spruce	c1	0.47	0.02	0.51	0.63	0.00	**0.15**
Low-bush cranberry aspen	d1	0.74	0.00	0.49	0.62	0.92	**0.47**
Spruce	d2	0.57	0.33	0.51	0.79	0.89	**0.34**
Low-bush cranberry white spruce	d3	0.70	0.61	0.54	0.88	0.97	**0.39**
Dogwood balsam poplar-aspen	e1	0.87	0.05	0.56	0.16	0.98	**0.66**
Spruce	e2	0.73	0.48	0.57	0.50	1.00	**0.60**
Dogwood white spruce	e3	0.69	0.00	0.64	0.79	0.91	**0.52**
Horsetail white spruce	f3	0.26	0.09	0.45	0.81	1.00	**0.22**
Spruce - jack pine	g1	0.35	0.03	0.50	0.57	0.00	**0.16**
Spruce - black spruce	h1	0.26	0.34	0.37	0.63	0.00	**0.14**
Wetland systems							
Wooded bog	i1	0.18	0.00	0.40	0.07	0.00	**0.11**
Forested fen	j1 k1	0.24	0.00	0.28	0.57	0.65	**0.14**
Gramminoid fen	k3	0.06	0.00	0.70	0.00	0.00	**0.07**
Shrubby fen	j2 k2	0.15	0.00	0.65	0.00	0.87	**0.37**
Wooded fen with internal lawns	j1 k1	0.12	0.00	0.46	0.14	0.83	**0.20**
Wooded fen	j1 k1	0.23	0.04	0.44	0.26	0.86	**0.29**
Marsh	i1	0.15	0.00	0.90	0.00	0.00	**0.16**
Shrubby swamp	-	0.26	0.00	0.82	0.00	0.96	**0.67**
Wooded swamp	-	0.31	0.54	0.71	0.82	0.92	**0.39**
Shallow open water	-	0.01	0.00	0.93	0.00	0.00	**0.00**
Other systems							
Shrubland	-	0.53	0.00	0.57	0.00	0.85	**0.62**
Meadow	-	0.01	0.00	0.57	0.00	0.00	**0.00**
Jack pine - larch complex	-	0.39	0.03	0.46	0.64	0.00	**0.20**
Sand	-	0.02	0.00	0.60	0.00	0.00	**0.00**
Lake	-	0.01	0.00	0.85	0.00	0.00	**0.00**
River	-	0.01	0.00	0.90	0.00	0.00	**0.00**
Cutbank	-	0.01	0.00	0.58	0.00	0.00	**0.00**

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[154] Suncor Energy Inc. 2005

Appendix E—Revegetation Considerations for Traditional Land-Use

In the context of the AOSR, traditional land-use (TLU) refers to established uses by Aboriginal peoples (First Nations and Métis) through generations of custom, belief, knowledge, and experience, often handed down to posterity through oral means (adapted from OSMELUC 1998). It is a term for a collection of land based activities that involve the simultaneous proximal use of multiple resources which help sustain the economic, cultural, and spiritual foundation of Aboriginal life. Traditional land-uses in the oil sands mining area targeted in this manual include:

- Trapping,
- Hunting ,
- Fishing (streams, rivers, and lakes),
- Medicinal plant harvesting,
- Food plant harvesting,
- Use of trails and site access, and
- Use of observation sites for wildlife.

Revegetation of disturbed areas in the AOSR, as it pertains to traditional land use, involves both ecological and anthropogenic considerations. Although this manual focuses primarily on a stand-level approach to revegetation of reclaimed upland sites, this integration of ecological and human requirements is a unique aspect of the reclamation and revegetation process that necessitates a landscape-level approach to meet the needs of both people and the environment. For example, habitat reclamation for particular ungulates will help support hunting opportunities only if access to hunting sites is possible. The following aspects of traditional land-use underscore the need for such an approach to revegetation practices:

1. Landscape-level use and distribution - traditional land-use has seasonal and spatial variation. Both the time of year and the type of activity influence the location where the activity occurs. For example, hunting, fishing, and plant gathering that occur in the summer months occur at a different location than trapping and hunting in the winter. The utility of sites for traditional use is defined not only by their internal characteristics, but by characteristics of adjacent landscape units (e.g., distribution of neighbouring ecosites or other habitat or use features such as water sources, or calving areas). Revegetation of reclaimed habitat that integrates site-specific concerns with landscape-level considerations will promote opportunities for ongoing traditional land use.

2. Wildlife habitat - many traditional land-uses are closely linked with or directly dependent upon wildlife habitat (for example, berry picking and hunting, respectively) and movement across the landscape is integral to traditional land use activities. For example, large game hunting follows animal movement patterns. Multiple ecosites are necessary to sustain animal habitat and associated hunting activities. The creation of good quality habitat whose abundance and distribution are consistent with pre-disturbance levels provides the best opportunity

for supporting healthy populations of wildlife species and the re-establishment of traditional land use practices on reclaimed post-mining areas.

3. Access – access is critical to successful practice of traditional land use activities. This includes the ability to travel across the landscape, as well as access to traditional land use areas from residential communities.

4. Abundance of species – although this manual deals principally with presence of vegetation species appropriate to given ecosites or site types (with the exception of establishment-density expectations for overstory species), abundance of traditionally used species is an important factor in the utility of a site targeted for traditional land use. In general, increasing densities (through increased planting/seeding densities or through use of density-promoting revegetation techniques such as direct placement of LFH amendments) of traditional use species on sites with a primary traditional use designation will increase the utility of these sites and thus the success of reclamation for this end land use.

Despite the above considerations, at this time the manual provides little guidance on landscape-level approaches to revegetation for traditional uses or other applications. Operators are encouraged to further develop and refine the recommendations contained in this appendix and manual for traditional use revegetation planning and integrate this guidance into landscape-level, site-specific closure planning to produce landscapes that are capable of supporting traditional end land uses.

Traditional land uses are not exclusive of other land uses. It is anticipated that sites with declared primary end land uses of commercial forestry or wildlife habitat will provide some traditional use value. In particular, there is significant overlap between wildlife habitat and traditional use; by reclaiming specific elements of wildlife habitat, operators will also be improving opportunities for traditional use. This appendix is intended to provide information additional to ecosystem-based revegetation planning and wildlife habitat guidance. Table E.1 provides initial guidance for revegetation practices that support traditional land use at both a stand- and landscape-level. Table E.2 provides lists of traditional plant species, by ecosite, derived from consultation with the Fort McKay First Nation. These lists are extensive (> 100 species in total) and include all commercially important tree species, and many of the species deemed important for wildlife habitat. These lists are intended to guide species selection for sites where traditional use is an end land-use objective, based on target ecosites.

Table E.1 Recommendations to develop revegetation practices that support traditional land-use at both a sand- and landscape-level

Action	Targeted TLU	Recommendation/Comment
Ensure establishment of plant species used for traditional purposes	1. Medicinal plant harvesting 2. Food plant harvesting	a) Develop a list of priority plant species for traditional use. Engage in conversations with regional community members/representatives to develop a list of priority species based on targeted ecosites. This will help refine the more comprehensive list of traditionally used species in Table E.2 and increase the selection of plant species people would like to use for food, medicine and spiritual purposes. Consider likelihood of species reestablishment during these conversations. b) Plant understory species with necessary abundance to support harvesting
Link TLU with wildlife habitat	1. Hunting 2. Trapping	a) Develop a list of priority animal species used for hunting and trapping. Similar to above, work in collaboration with regional Aboriginal communities to identify which species community members would most like to target for reestablishment. Reference Appendix D: Design Elements for Wildlife Habitat to ensure necessary animal forage species are also established. b) Consider the need for limited access or protection for certain wildlife, as appropriate. There may be special considerations for wildlife with particular conservation status.
Support human use of landscape by employing a landscape level approach to revegetation	1. All uses	While many of the key issues related to revegetation for TLU are addressed when targeting wildlife use, there are unique considerations for supporting human use of the landscape, many of which may only be addressed with a landscape level approach. Address (when possible) the following issues: a) *Access both within and across revegetated sites.* b) *Likelihood of increasing site biodiversity (e.g., available seed sources).* Traditional land use relies on a diversity of resources available in a given location. Ensure a diversity of plant and animal species are available to traditional use. This may be most achievable when assessing resources established at multiple ecosites rather than within a single stand. c) *Seasonal traditional use of the landscape.* TLU has seasonal and spatial variation. Both the time of year and the type of activity influence the location where the activity occurs. Discuss with community members resources they use at different times of the year and where on the landscape they occur. Consider the findings when developing revegetation plans. d) *Similarity to pre-disturbance habitat types.* Aboriginal community members continuously state the importance of landscape biodiversity ("everything is important") and frequently encourage the establishment of species that were in place prior to disturbance.
Integrate upland revegetation with wetland and riparian reclamation	1. Fishing 2. Medicinal plant harvesting 3. Food plant harvesting 4. Hunting 5. Trails and site access	a) Consider access to water for both people and wildlife in landscape design.
Landform/terrain	1. Use of observation sites for wildlife 2. Hunting	a) Ensure terrain provides for animal and human movement within and across sites.

Table E. 2 **List of traditional plant species as identified by the Fort McKay First Nation[186] associated with ecosite a**

Scientific Name	Traditional or Common Name(s)	Characteristic Species to ecosite a
Tree Stratum		
Abies balsamifera	balsam fir	
Betula papyrifera	white birch, paper birch, canoe birch	
Larix laricina	tamarack	
Picea glauca	white spruce	
Picea mariana	black spruce	
Pinus banksiana	Jack pine	✓
Populus tremuloides	white poplar; quacking aspen; trembling aspen	
Shrub Stratum		
Alnus viridis	green alder	✓
Arctostaphylos uva-ursi	chicken berry; bearberry; muskeg wiregrass	✓
Cornus stolonifera	red willow; red-osier dogwood	
Ledum groenlandicum	Labrador tea, muskeg tea	✓
Lonicera dioica	twining honeysuckle	
Lonicera involucrata	bracted honeysuckle	
Prunus pensylvanica	pin cherry	
Prunus virginiana	choke cherry	
Ribes triste	mooseberry, wild red current; eye berry	
Rosa acicularis	rose; prickly rose	
Rubus idaeus	raspberry	
Salix spp. (including *S. exigua, S. lasiandra*)	willow	
Sheperdia canadensis	buffaloberry, soapberry	
Vaccinium myrtilloides (and others)	blueberry; huckleberry	✓
Vaccinium vitis-idaea	cranberry; mountain cranberry; bog cranberry	✓
Forb Stratum		
Achillea millefolium	common yarrow	
Aralia nudicaulis	wild sarsaparilla; rabbit root	
Aster laevis	smooth aster	
Campanula rotundifolia	harebell	
Cornus canadensis	bunchberry; mustache berry	
Epilobium angustifolium	fireweed	
Equisetum spp.	horsetail	
Fragaria vesca	woodland strawberry	
Fragaria virginiana	wild strawberry	
Galium boreale	northern bedstraw	
Lilium philadelphicum var. *andinum*	wood lily	
Lycopodium spp. (*L. annotinum, L. clavatum* or *L. obscurum*)	club moss; ground pine; stiff clubmoss	
Mitella nuda	bishop's cap; common mitrewort	
Pyrola asarifolia	pink wintergreen	

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[186] Note: this traditional plant list cannot be reproduced, quoted or cited without written authorization from the Fort McKay IRC.

Scientific Name	**Traditional or Common Name(s)**	**Characteristic Species to ecosite a**
Grass Stratum		
Calamagrostis canadensis	bluejoint	
Moss Stratum		
Hylocomium splendens	stair-step moss	
Lichen Stratum		
Cladina rangiferina; Cladina stellaris	reindeer lichen; caribou moss	✓
Peltigera apthosa	freckle pelt lichen	✓
Usnea spp.	old man's beard	✓

denotes species for which fact sheets are available in Appendix F

✓ denotes species designated as a characteristic species for the ecosite (See Sections 3 and 4)

Table E. 3 **List of traditional plant species as identified by the Fort McKay First Nation[156] associated with ecosite b**

Scientific Name	Traditional or Common Name(s)	Characteristic Species to ecosite a
Tree Stratum		
Abies balsamifera	balsam fir	
Betula papyrifera	white birch, paper birch, canoe birch	✓
Picea glauca	white spruce	✓
Picea mariana	black spruce	
Pinus banksiana	Jack pine	✓
Populus balsamifera	balsam poplar; black poplar	
Populus tremuloides	white poplar; quacking aspen; trembling aspen	✓
Shrub Stratum		
Actaea rubra	baneberry	
Alnus viridis	green alder	✓
Alnus incana ssp. *tenuifolia*	river alder	
Amelanchier alnifolia	saskatoon	✓
Arctostaphylos uva-ursi	chicken berry; bearberry; muskeg wiregrass	✓
Juniperus communis	juniper	
Ledum groenlandicum	Labrador tea, muskeg tea	
Lonicera dioica	twining honeysuckle	
Lonicera involucrata	bracted honeysuckle	
Prunus pensylvanica	pin cherry	
Prunus virginiana	choke cherry	
Ribes triste	mooseberry, wild red current; eye berry	
Rosa acicularis	rose; prickly rose	✓
Rubus idaeus	raspberry	
Rubus pubescens	trailing raspberry; dewberry	
Salix spp. (including *S. exigua, S. lasiandra*)	willow	✓
Sheperdia canadensis	buffaloberry, soapberry	✓
Symphoricarpos albus	snowberry; "wolf berry; buckbrush	
Vaccinium myrtilloides (and others)	blueberry; huckleberry	✓
Vaccinium vitis-idaea	cranberry; mountain cranberry; bog cranberry	✓
Viburnum edule	moose berry; lowbush cranberry; highbush cranberry	
Forb Stratum		
Achillea millefolium	common yarrow	
Aralia nudicaulis	wild sarsaparilla; rabbit root	✓
Aster conspicuus	showy aster	
Campanula rotundifolia	harebell	
Cornus canadensis	bunchberry; mustache berry	✓
Epilobium angustifolium	fireweed	✓
Equisetum spp.	horsetail	
Fragaria virginiana	wild strawberry	
Galium boreale	northern bedstraw	

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[156] Note, this traditional plant list cannot be reproduced, quoted or cited without written authorization from the Fort McKay IRC

Scientific Name	Traditional or Common Name(s)	Characteristic Species to ecosite a
Galium triflorum	sweet-scented bedstraw	
Lilium philadelphicum var. andinum	wood lily	
Lycopodium spp. (*L. annotinum*, *L. clavatum* or *L. obscurum*)	club moss; ground pine; stiff clubmoss	
Mitella nuda	bishop's cap; common mitrewort	
Pyrola asarifolia	pink wintergreen	
Solidago canadensis; Solidago spathulata	goldenrod	
Streptopus amplexifolius	twisted stalk	
Grass Stratum		
Calamagrostis canadensis	bluejoint	✓
Hierochloe hirta ssp. *arctica*	sweet grass	
Moss Stratum		
Hylocomium splendens	stair-step moss	✓
Lichen Stratum		
Cladina rangiferina; Cladina stellaris	reindeer lichen; caribou moss	✓
Peltigera apthosa	freckle pelt lichen	
Usnea spp.	old man's beard	

denotes species for which fact sheets are available in Appendix F

✓ denotes species designated as a characteristic species for the ecosite (See Sections 3 and 4)

Table E. 4 List of traditional plant species as identified by the Fort McKay First Nation[157] associated with ecosite c

Scientific Name	Traditional or Common Name(s)	Characteristic Species to ecosite a
Tree Stratum		
Abies balsamifera	balsam fir	
Betula papyrifera	white birch, paper birch, canoe birch	
Betula glandulosa (nana),	bog birch	
Betula. pumila var. glandulifera	dwarf birch	
Picea glauca	white spruce	
Picea mariana	black spruce	✓
Pinus banksiana	Jack pine	✓
Populus balsamifera	balsam poplar; black poplar	
Populus tremuloides	white poplar; quacking aspen; trembling aspen	
Shrub Stratum		
Alnus viridis	green alder	✓
Alnus incana ssp. *tenuifolia*	river alder	
Amelanchier alnifolia	saskatoon	
Arctostaphylos uva-ursi	chicken berry; bearberry; muskeg wiregrass	
Empetrum nigrum	crowberry; otterberry	✓
Ledum groenlandicum	Labrador tea, muskeg tea	✓
Prunus pensylvanica	pin cherry	
Rosa acicularis	rose; prickly rose	✓
Rubus idaeus	raspberry	
Rubus pubescens	trailing raspberry; dewberry	
Salix spp. (including *S. exigua, S. lasiandra*)	willow	✓
Sheperdia canadensis	buffaloberry, soapberry	
Vaccinium myrtilloides (and others)	blueberry; huckleberry	✓
Vaccinium vitis-idaea	cranberry; mountain cranberry; bog cranberry	✓
Viburnum edule	moose berry; lowbush cranberry; highbush cranberry	
Forb Stratum		
Achillea millefolium	common yarrow	
Aralia nudicaulis	wild sarsaparilla; rabbit root	
Campanula rotundifolia	harebell	
Cornus canadensis	bunchberry; mustache berry	✓
Epilobium angustifolium	fireweed	
Equisetum spp.	horsetail	✓
Fragaria virginiana	wild strawberry	
Galium boreale	northern bedstraw	
Lilium philadelphicum var. *andinum*	wood lily	
Lycopodium spp. (*L. annotinum, L clavatum* or *L. obscurum*)	club moss; ground pine; stiff clubmoss	✓
Pyrola asarifolia	pink wintergreen	✓

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[157] Note, this traditional plant list cannot be reproduced, quoted or cited without written authorization from the Fort McKay IRC

Scientific Name	**Traditional or Common Name(s)**	**Characteristic Species to ecosite a**
Grass Stratum		
Calamagrostis canadensis	bluejoint	
Moss Stratum		
Hylocomium splendens	stair-step moss	✓
Sphagnum spp.	sphagnum moss; muskeg	
Lichen Stratum		
Cladina rangiferina; Cladina stellaris	reindeer lichen; caribou moss	✓
Peltigera apthosa	freckle pelt lichen	
Usnea spp.	old man's beard	

denotes species for which fact sheets are available in Appendix F

✓ denotes species designated as a characteristic species for the ecosite (See Sections 3 and 4)

Table E. 5 **List of traditional plant species as identified by the Fort McKay First Nation[158] associated with ecosite d**

Scientific Name	Traditional or Common Name(s)	Characteristic Species to ecosite a
Tree Stratum		
Abies balsamifera	balsam fir	✓
Betula papyrifera	white birch, paper birch, canoe birch	✓
Betula glandulosa (nana),	bog birch	
Larix laricina	tamarack	
Picea glauca	white spruce	✓
Picea mariana	black spruce	✓
Pinus banksiana	Jack pine	
Pinus contorta var. *latifolia*	lodgepole pine	
Populus balsamifera	balsam poplar; black poplar	✓
Populus tremuloides	white poplar; quacking aspen; trembling aspen	✓
Shrub Stratum		
Actaea rubra	baneberry	
Alnus viridis	green alder	✓
Alnus incana ssp. *tenuifolia*	river alder	
Amelanchier alnifolia	saskatoon	✓
Arctostaphylos uva-ursi	chicken berry; bearberry; muskeg wiregrass	
Cornus stolonifera	red willow; red-osier dogwood	
Corylus cornuta	beaked hazelnut	✓
Ledum groenlandicum	Labrador tea, muskeg tea	✓
Lonicera dioica	twining honeysuckle	
Lonicera involucrata	bracted honeysuckle	
Oxycoccus microcarpus	small bog cranberry	
Potentilla fruticosa	shrubby cinquefoil	
Prunus pensylvanica	pin cherry	
Prunus virginiana	choke cherry	
Ribes hudsonianum	black current	
Ribes lacustre	black gooseberry	✓
Ribes oxyacanthoides	northern gooseberry	✓
Ribes triste	mooseberry, wild red current; eye berry	✓
Rosa acicularis	rose; prickly rose	✓
Rubus arcticus	dwarf raspberry	
Rubus idaeus	raspberry	✓
Rubus pubescens	trailing raspberry; dewberry	✓
Salix spp. (including *S. exigua, S. lasiandra*)	willow	✓
Sheperdia canadensis	buffaloberry, soapberry	✓
Symphoricarpos albus	snowberry, "wolf berry; buckbrush	✓
Vaccinium caespitosum	blueberry	
Vaccinium myrtilloides (and others)	blueberry; huckleberry	
Vaccinium vitis-idaea	cranberry; mountain cranberry; bog cranberry	

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[158] Note, this traditional plant list cannot be reproduced, quoted or cited without written authorization from the Fort McKay IRC.

Scientific Name	Traditional or Common Name(s)	Characteristic Species to ecosite a
Viburnum edule	moose berry; lowbush cranberry; highbush cranberry	✓
Viburnum opulus	highbush cranberry	
Forb Stratum		
Achillea millefolium	common yarrow	
Achillea sibirica	Siberian yarrow	
Aralia nudicaulis	wild sarsaparilla; rabbit root	✓
Aster conspicuus	showy aster	✓
Campanula rotundifolia	harebell	
Cirsium arvense	Canada thistle	
Cornus canadensis	bunchberry; mustache berry	✓
Disporum trachycarpum	fairybells	
Dryopteris carthusiana	spinulose shield fern	
Epilobium angustifolium	fireweed	✓
Equisetum spp.	horsetail	
Fragaria vesca	woodland strawberry	
Fragaria virginiana	wild strawberry	✓
Galium boreale	northern bedstraw	
Galium triflorum	sweet-scented bedstraw	✓
Geranium bicknellii	Bicknell's geranium	
Heracleum lanatum	cow parsnip	
Lilium philadelphicum var. andinum	wood lily	
Lycopodium spp. (*L. annotinum, L. clavatum* or L. *obscurum*)	club moss; ground pine; stiff clubmoss	
Matteuccia struthiopterus	ostrich fern	
Mitella nuda	bishop's cap; common mitrewort	
Pyrola asarifolia	pink wintergreen	✓
Pyrola elliptica	white wintergreen	
Solidago canadensis; Solidago spathulata	goldenrod	
Streptopus amplexifolius	twisted stalk	
Urtica dioica	nettle	
Grass Stratum		
Calamagrostis canadensis	bluejoint	✓
Moss Stratum		
Hylocomium splendens	stair-step moss	✓
Sphagnum spp.	sphagnum moss; muskeg	
Lichen Stratum		
Cladina rangiferina; Cladina stellaris	reindeer lichen; caribou moss	
Cladonia botrytes	stump cladonia	
Peltigera apthosa	freckle pelt lichen	
Usnea spp.	old man's beard	

denotes species for which fact sheets are available in Appendix F

✓ denotes species designated as a characteristic species for the ecosite (See Sections 3 and 4)

Table E. 6 List of traditional plant species as identified by the Fort McKay First Nation[159] associated with ecosite e

Scientific Name	Traditional or Common Name(s)	Characteristic Species to ecosite a
Tree Stratum		
Abies balsamifera	balsam fir	✓
Betula papyrifera	white birch, paper birch, canoe birch	✓
Betula glandulosa (nana).	bog birch	
Larix laricina	tamarack	
Picea glauca	white spruce	✓
Picea mariana	black spruce	
Pinus banksiana	Jack pine	
Pinus contorta var. *latifolia*	lodgepole pine	
Populus balsamifera	balsam poplar; black poplar	✓
Populus tremuloides	white poplar; quacking aspen; trembling aspen	✓
Shrub Stratum		
Actaea rubra	baneberry	
Alnus viridis	green alder	✓
Alnus incana ssp. *tenuifolia*	river alder	✓
Amelanchier alnifolia	saskatoon	✓
Arctostaphylos uva-ursi	chicken berry; bearberry; muskeg wiregrass	
Cornus stolonifera	red willow; red-osier dogwood	✓
Corylus cornuta	beaked hazelnut	
Ledum groenlandicum	Labrador tea, muskeg tea	
Lonicera dioica	twining honeysuckle	✓
Lonicera involucrata	bracted honeysuckle	
Oxycoccus microcarpus	small bog cranberry	
Prunus virginiana	choke cherry	
Ribes hudsonianum	black current	✓
Ribes lacustre	black gooseberry	✓
Ribes oxyacanthoides	northern gooseberry	✓
Ribes triste	mooseberry, wild red current; eye berry	
Rosa acicularis	rose; prickly rose	✓
Rubus idaeus	raspberry	✓
Rubus pubescens	trailing raspberry; dewberry	✓
Salix spp. (including *S. exigua, S. lasiandra*)	willow	✓
Sheperdia canadensis	buffaloberry, soapberry	
Symphoricarpos albus	snowberry; "wolf berry; buckbrush	
Vaccinium caespitosum	blueberry	
Vaccinium myrtilloides (and others)	blueberry; huckleberry	
Vaccinium vitis-idaea	cranberry; mountain cranberry; bog cranberry	
Viburnum edule	moose berry; lowbush cranberry; highbush cranberry	✓
Viburnum opulus	highbush cranberry	

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[159] Note, this traditional plant list cannot be reproduced, quoted or cited without written authorization from the Fort McKay IRC

Scientific Name	**Traditional or Common Name(s)**	**Characteristic Species to ecosite a**
Forb Stratum		
Achillea millefolium	common yarrow	
Aralia nudicaulis	wild sarsaparilla; rabbit root	✓
Aster conspicuus	showy aster	
Cirsium arvense	Canada thistle	
Cornus canadensis	bunchberry; mustache berry	✓
Disporum trachycarpum	fairybells	
Dryopteris carthusiana	spinulose shield fern	
Epilobium angustifolium	fireweed	✓
Equisetum spp.	horsetail	✓
Fragaria vesca	woodland strawberry	
Fragaria virginiana	wild strawberry	
Galium boreale	northern bedstraw	
Galium triflorum	sweet-scented bedstraw	
Heracleum lanatum	cow parsnip	
Lycopodium spp. (*L. annotinum, L. clavatum* or L. obscurum)	club moss; ground pine; stiff clubmoss	
Mitella nuda	bishop's cap; common mitrewort	✓
Pyrola asarifolia	pink wintergreen	
Grass Stratum		
Calamagrostis canadensis	bluejoint	✓
Scirpus spp.	bulrush	
Moss Stratum		
Hylocomium splendens	stair-step moss	
Sphagnum spp.	sphagnum moss; muskeg	
Lichen Stratum		
Peltigera apthosa	freckle pelt lichen	
Usnea spp.	old man's beard	

denotes species for which fact sheets are available in Appendix F

✓ denotes species designated as a characteristic species for the ecosite (See Sections 3 and 4)

Table E. 7 **List of traditional plant species as identified by the Fort McKay First Nation[160] associated with ecosite f**

Scientific Name	Traditional or Common Name(s)	Characteristic Species to ecosite a
Tree Stratum		
Abies balsamifera	balsam fir	✓
Betula papyrifera	white birch, paper birch, canoe birch	✓
Picea glauca	white spruce	✓
Picea mariana	black spruce	
Pinus banksiana	Jack pine	
Pinus contorta var. *latifolia*	lodgepole pine	
Populus balsamifera	balsam poplar; black poplar	✓
Populus tremuloides	white poplar; quacking aspen; trembling aspen	✓
Shrub Stratum		
Actaea rubra	baneberry	
Alnus viridis	green alder	✓
Alnus incana ssp. *tenuifolia*	river alder	
Amelanchier alnifolia	saskatoon	
Cornus stolonifera	red willow; red-osier dogwood	✓
Ledum groenlandicum	Labrador tea, muskeg tea	
Lonicera dioica	twining honeysuckle	
Lonicera involucrata	bracted honeysuckle	
Prunus pensylvanica	pin cherry	
Ribes hudsonianum	black current	✓
Ribes lacustre	black gooseberry	✓
Ribes oxyacanthoides	northern gooseberry	✓
Ribes triste	mooseberry, wild red current; eye berry	
Rosa acicularis	rose; prickly rose	✓
Rubus arcticus	dwarf raspberry	
Rubus chamaemorus	muskegberry, cloudberry; frog berry	
Rubus idaeus	raspberry	✓
Rubus pubescens	trailing raspberry; dewberry	✓
Salix spp. (including *S. exigua, S. lasiandra*)	willow	✓
Sheperdia canadensis	buffaloberry, soapberry	
Symphoricarpos albus	snowberry; "wolf berry; buckbrush	
Vaccinium myrtilloides (and others)	blueberry; huckleberry	
Vaccinium vitis-idaea	cranberry; mountain cranberry, bog cranberry	
Viburnum edule	moose berry; lowbush cranberry; highbush cranberry	✓
Forb Stratum		
Achillea millefolium	common yarrow	
Aralia nudicaulis	wild sarsaparilla; rabbit root	✓
Aster conspicuus	showy aster	
Cornus canadensis	bunchberry; mustache berry	✓
Dryopteris carthusiana	spinulose shield fern	

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[160] Note, this traditional plant list cannot be reproduced, quoted or cited without written authorization from the Fort McKay IRC

Scientific Name	**Traditional or Common Name(s)**	**Characteristic Species to ecosite a**
Epilobium angustifolium	fireweed	
Equisetum spp.	horsetail	✓
Fragaria virginiana	wild strawberry	
Galium boreale	northern bedstraw	
Galium triflorum	sweet-scented bedstraw	
Heracleum lanatum	cow parsnip	
Lycopodium spp. (L. annotinum, L. clavatum or L. obscurum)	club moss; ground pine; stiff clubmoss	
Mitella nuda	bishop's cap; common mitrewort	
Pyrola asarifolia	pink wintergreen	
Urtica dioica	nettle	
Grass Stratum		
Calamagrostis canadensis	bluejoint	✓
Typha latifolia	cattail	
Moss Stratum		
Hylocomium splendens	stair-step moss	✓
Sphagnum spp.	sphagnum moss; muskeg	
Lichen Stratum		
Peltigera apthosa	freckle pelt lichen	
Usnea spp.	old man's beard	

denotes species for which fact sheets are available in Appendix F

✓ denotes species designated as a characteristic species for the ecosite (See Sections 3 and 4)

Table E. 8 **List of traditional plant species as identified by the Fort McKay First Nation[161] associated with ecosite g**

Scientific Name	**Traditional or Common Name(s)**	**Characteristic Species to ecosite a**
Tree Stratum		
Abies balsamifera	balsam fir	
Betula papyrifera	white birch, paper birch, canoe birch	✓
Betula glandulosa (nana).	bog birch	
Betula. pumila var. glandulifera	dwarf birch	
Larix laricina	tamarack	
Picea glauca	white spruce	
Picea mariana	black spruce	✓
Pinus banksiana	Jack pine	✓
Pinus contorta var. latifolia	lodgepole pine	
Populus balsamifera	balsam poplar; black poplar	
Populus tremuloides	white poplar; quacking aspen; trembling aspen	
Shrub Stratum		
Alnus viridis	green alder	
Amelanchier alnifolia	saskatoon	
Arctostaphylos uva-ursi	chicken berry; bearberry; muskeg wiregrass	
Empetrum nigrum	crowberry; otterberry	
Ledum groenlandicum	Labrador tea, muskeg tea	✓
Lonicera dioica	twining honeysuckle	
Lonicera involucrata	bracted honeysuckle	
Oxycoccus microcarpus	small bog cranberry	
Potentilla fruticosa	shrubby cinquefoil	
Ribes hudsonianum	black current	
Rosa acicularis	rose; prickly rose	✓
Rubus arcticus	dwarf raspberry	
Rubus chamaemorus	muskegberry, cloudberry; frog berry	
Rubus pubescens	trailing raspberry; dewberry	
Salix spp. (including *S. exigua, S. lasiandra*)	willow	
Sheperdia canadensis	buffaloberry, soapberry	
Symphoricarpos albus	snowberry; "wolf berry; buckbrush	
Vaccinium caespitosum	blueberry	
Vaccinium myrtilloides (and others)	blueberry; huckleberry	✓
Vaccinium vitis-idaea	cranberry; mountain cranberry; bog cranberry	✓
Viburnum edule	moose berry; lowbush cranberry; highbush cranberry	
Forb Stratum		
Achillea millefolium	common yarrow	
Campanula rotundifolia	harebell	
Cornus canadensis	bunchberry; mustache berry	✓
Epilobium angustifolium	fireweed	
Equisetum spp.	horsetail	✓

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[161] Note, this traditional plant list cannot be reproduced, quoted or cited without written authorization from the Fort McKay IRC

Scientific Name	**Traditional or Common Name(s)**	**Characteristic Species to ecosite a**
Fragaria vesca	woodland strawberry	
Fragaria virginiana	wild strawberry	
Galium boreale	northern bedstraw	
Lycopodium spp. (*L. annotinum, L. clavatum* or *L. obscurum*)	club moss; ground pine; stiff clubmoss	
Mitella nuda	bishop's cap; common mitrewort	
Grass Stratum		
Calamagrostis canadensis	bluejoint	
Moss Stratum		
Hylocomium splendens	stair-step moss	✓
Sphagnum spp.	sphagnum moss; muskeg	✓
Lichen Stratum		
Cladina rangiferina; Cladina stellaris	reindeer lichen; caribou moss	✓
Cladonia botrytes	stump cladonia	
Peltigera apthosa	freckle pelt lichen	
Usnea spp.	old man's beard	

denotes species for which fact sheets are available in Appendix F

✓ denotes species designated as a characteristic species for the ecosite (See Sections 3 and 4)

Table E. 9 List of traditional plant species as identified by the Fort McKay First Nation[162] associated with ecosite h

Scientific Name	Traditional or Common Name(s)	Characteristic Species to ecosite a
Tree Stratum		
Abies balsamifera	balsam fir	
Betula papyrifera	white birch, paper birch, canoe birch	
Betula. pumila var. glandulifera	dwarf birch	
Larix laricina	tamarack	
Picea glauca	white spruce	✓
Picea mariana	black spruce	✓
Pinus banksiana	Jack pine	
Pinus contorta var. latifolia	lodgepole pine	
Populus tremuloides	white poplar; quacking aspen; trembling aspen	
Shrub Stratum		
Actaea rubra	baneberry	
Alnus viridis	green alder	
Alnus incana ssp. *tenuifolia*	river alder	
Amelanchier alnifolia	saskatoon	
Arctostaphylos uva-ursi	chicken berry; bearberry; muskeg wiregrass	
Cornus stolonifera	red willow; red-osier dogwood	
Ledum groenlandicum	Labrador tea, muskeg tea	✓
Lonicera dioica	twining honeysuckle	
Lonicera involucrata	bracted honeysuckle	
Oxycoccus microcarpus	small bog cranberry	
Ribes hudsonianum	black current	
Ribes lacustre	black gooseberry	
Ribes oxyacanthoides	northern gooseberry	
Ribes triste	mooseberry, wild red current; eye berry	
Rosa acicularis	rose; prickly rose	✓
Rubus arcticus	dwarf raspberry	
Rubus chamaemorus	muskegberry, cloudberry; frog berry	
Rubus idaeus	raspberry	
Rubus pubescens	trailing raspberry; dewberry	
Salix spp. (including *S. exigua, S. lasiandra*)	willow	✓
Sheperdia canadensis	buffaloberry, soapberry	
Vaccinium myrtilloides (and others)	blueberry; huckleberry	
Vaccinium vitis-idaea	cranberry; mountain cranberry; bog cranberry	✓
Viburnum edule	moose berry; lowbush cranberry; highbush cranberry	
Forb Stratum		
Achillea millefolium	common yarrow	
Campanula rotundifolia	harebell	
Cornus canadensis	bunchberry; mustache berry	✓
Epilobium angustifolium	fireweed	

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[162] Note, this traditional plant list cannot be reproduced, quoted or cited without written authorization from the Fort McKay IRC.

Scientific Name	**Traditional or Common Name(s)**	**Characteristic Species to ecosite a**
Equisetum spp.	horsetail	✓
Fragaria virginiana	wild strawberry	
Galium boreale	northern bedstraw	
Galium triflorum	sweet-scented bedstraw	
Lycopodium spp. (*L. annotinum, L. clavatum* or L. obscurum)	club moss; ground pine; stiff clubmoss	
Mitella nuda	bishop's cap; common mitrewort	
Pyrola asarifolia	pink wintergreen	
Grass Stratum		
Calamagrostis canadensis	bluejoint	✓
Moss Stratum		
Hylocomium splendens	stair-step moss	✓
Sphagnum spp.	sphagnum moss; muskeg	
Lichen Stratum		
Peltigera apthosa	freckle pelt lichen	
Usnea spp.	old man's beard	

denotes species for which fact sheets are available in Appendix F

✓ denotes species designated as a characteristic species for the ecosite (See Sections 3 and 4)

Table E. 10 List of traditional plant species as identified by the Fort McKay First Nation[163] not common to upland ecosites a through h

Scientific Name	Traditional or Common Name(s)	Characteristic Species to ecosite a
Tree Stratum		
Sorbus scopulina	western mountain ash	
Shrub Stratum		
Elaeagnus commutata	wolf willow	
Forb Stratum		
Acorus americanus	rat root; sweet flag	
Anemone riparia	tall anemone	
Artemisia frigida	pasture sagewort	✓
Chenopodium capitatum	strawberry blight	
Cicuta maculata var. angustifolia	water hemlock	✓
Dracocephalum parviflorum	muskekee/eye medicine	
Maticaria matricariodes	chamomile	
Mentha arvensis	wildmint	
Nuphar variegatum	small yellow pond lily	
Petasites vitifolius	vine-leaved coltsfoot	
Plantago major	plantain	
Polygala senega	senega snakeroot	
Rumex occidentalis	western dock	
Sagittaria cuneata	wapato	
Sarracenia purpurea	frog plant, pitcher plant; green frog plant; frog pail	
Species unknown	ground berry	
Species unknown	sweet potato	

Table E. 11 List of traditional fungi species as identified by the Fort McKay First Nation[163]

Scientific Name	Traditional or Common Name(s)	Characteristic Species to ecosite a
Fungi		
Fomes fomentarius	white poplar fungus; touchwood fungus	
Fomes pinicola	bracted fungus	
Fomitopsis pinicola	smudge fungus	✓
Lenzites betulina	willow fungus	
Lycoperdon perlatum	puffball	✓
Polyporaceae spp.	willow fungus	

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[163] Note, this traditional plant list cannot be reproduced, quoted or cited without written authorization from the Fort McKay IRC

Appendix F—Plant Species Fact Sheets

Introduction

All of the profiles include a set of information that has been drawn from a number of sources. The primary source of information is a study by Wild Rose Consulting, Inc. (Edmonton) 'Native Plant Propagation and Establishment' ilnitiated and funded by Syncrude Canada, Ltd. in 2000 and later (2007) transferred to the auspices of CONRAD (Canadian Oil Sands Network for Research and Development). This work is continuing and will yield more precise information as the project continues. Literature searches were undertaken to obtain further information and sources of specific data are cited in the profiles.

The following information, if available, is included in each profile.

Nomenclature

Scientific Name – indicates the internationally accepted scientific binomial by which each species is known. The scientific names presented correspond to the Alberta Natural Heritage Information Centre list of all valscular plant elements (ANHIC 2006).

Family – the plant family to which each species is assigned.

Common Names – there are no standard common names for plants and the most widely used common names for each species in the oil sands area are included.

Description[164] – a comprehensive description of the plant with particular information about fruit and seeds.

Habitat[164] - a description of the ecological niche that each species inhabits; includes specific information on soil and moisture tolerances taken from the literature[165].

Distribution[164] - in Alberta, North America and worldwide.

Phenology - Information regarding flower and seed maturity times, particularly in northeastern Alberta.

Pollination - describes and list pollination vectors if known.

Genetics[164] - include ploidy levels of native populations.

Symbioses – incorporates information concerning known mycorrhizal or rhizobial partners.

Seed Processing - includes information on harvest methods and times, cleaning and storage methods and seed longevity. It also includes seed and fruit measures such as seed weights, fruit per volume or weight of fruit and average seeds in each fruit (primarily derived from evaluations of collection from northeastern Alberta. This information is taken from studies by Wild Rose Consulting, Inc. unless otherwise noted).

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[164] Most of the information listed in these categories has been gleaned from a few standard texts including 'Flora of Alberta' (Moss 1983) and 'Plants of the Western Boreal Forest' (Johnson et al. 1995).

[165] Much of the information for this section was gleaned from the 'Manual of Plant Species Suitability for Reclamation in Alberta -- 2nd Edition (Hardy BBT Limited 1989.)

Propagation - comprises information on natural reproduction (in situ), germination and pre-treatments, direct seeding and seeding rates and vegetative methods. Details on germination, pre-treatments and establishment on reclamation sites are derived from work by Wild Rose Consulting, Inc. unless noted otherwise.

Aboriginal Uses[166] - includes food, medicinal and sundry other uses.

Wildlife/Forage Uses – comprises information regarding use of the species by wildlife and by domestic livestock. It also indicates the plant's response to grazing if known.

Reclamation Role - includes any extra information about the use of the species in reclamation, particularly in Alberta.

Commercial Resources - indicates if plants or propagules are commercially available, describes commercial harvest methods if any exist, and also lists horticultural cultivars if any are available. Other commercial uses for the plant are also discussed.

Notes - includes any information that does not fit any of the other categories described above.

Photographs and Line Drawings[167] - most profiles contain photos and/or line diagrams showing various aspects of the plant species.

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[166] This information is primarily drawn from 'Aboriginal Plant Use in Canada's Northwest Boreal Forest' (Marles et al. 2000).

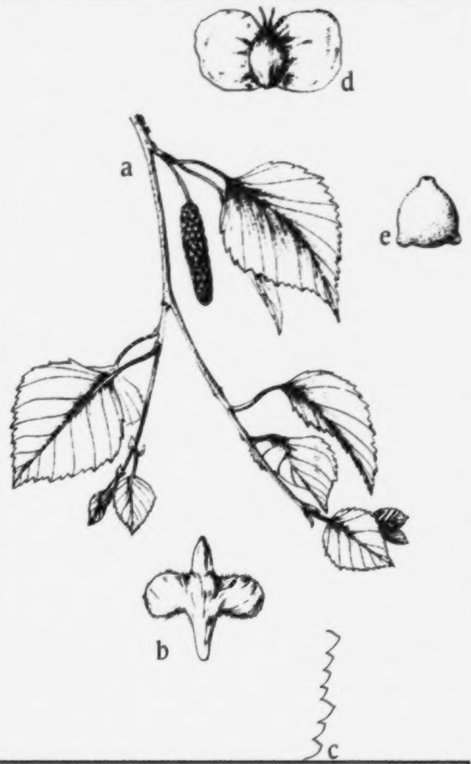
[167] Photographic credits are included at the bottom on each profile. Line drawings are used with permission of the University of Alberta Collections. The illustrator is John Maywood.

Scientific Name: **Family:** *Betulaceae*
Betula papyrifera Marsh
Common Names: paper birch, western birch, white birch

Plant Description

Perennial tree, up to 30 m high; trunk to 60 cm diam, bark white to red-brown, brown lenticels, peeling in sheets; dark brown branches with fuzzy twigs; oval to diamond-shaped leaves, 4-9 cm, toothed, fuzzy beneath, tufts of hair on vein axils; catkins, 2-3 cm.
Fruit: pendulous aments paired on spur shoots.
Seed: samaras, 3 per bract; flat, oblong, membranous winged nutlets, 2.5-3.5 mm x 1.5-2 mm (4-5 mm with wings), ridged, brown.

Betula papyrifera **often becomes a multi-stemmed tree.**



Betula papyrifera**. a. branch with leaves and seed catkin. b. cone bract. c. leaf margin. d. seed. e. pollen.**

Habitat and Distribution

Co-dominant in mixed woods with *Populus tremuloides, Picea mariana, Picea glauca, Pinus banksiana,* and *Abies balsamifera.* Prefers north or east facing slopes. Paper birch is shade intolerant and has high drought tolerance (Hardy BBT 1989).
Seral Stage: Can form pioneer stands on disturbed sites in boreal systems. (Hardy BBT 1989)
Soil: Grows on a variety of soil types, but best on well-drained deep, sandy or silty soils. Can tolerate moderate acidic soils to as low as pH 3.2 (Hardy BBT). Paper birch tolerates flood and drought (Gerling et al 1996).
Distribution: In Alberta, found in mountains, widespread across boreal forest and occasional in parkland; Alas, YT,

n Alta, n Sask, c Man, Gr Lakes, s to Wash, Mont, Colo, n Neb, Minn, Pa, NY. Widespread in central and northern Alberta forming pure stands on burned or cutover areas (Hardy BBT 1989).

Phenology

Flowers in mid-April to early June, seeds mature in August and September. Seeds disperse from August through the following spring (Young and Young 1992).

Pollination

Pollinated by wind

Genetics

2n=56, 84

Symbiosis

Ectomycorrhizal (Hagerman and Durall 2004). Birch trees may also serve as refuge for multi- and late-stage fungi (Kranabetter 1999).

Seed Processing

Collection: Catkins are easily stripped from branches. Pole–pruners are necessary to harvest from tall trees.
Seed Weight: 0.090-0.175 g/1000 seeds (0.152 avg).
Harvest Dates: Late July to September in northeastern Alberta. Ripe catkins will be green or yellow to brown in colour (Banerjee 2001).
Cleaning: Air-dry fruits/cones at 15-25°C. Crush material or remove large chaff and crush remaining material. Sieve to remove seeds from chaff using appropriate size screens (8/64 inch screen size (Young and Young 1992).
Storage: Store at cool temperatures (2-5°C) at 1-3% moisture (Young and Young 1992, Acharya *et al.* 1992).
Longevity: Seed can remain viable up to 3 years (Smreciu et al. 2003). Ughytil (1991) suggest that storage up to 8 years is possible when stored in sealed containers at 2-4°C at low moisture.

Propagation

Emerging seedling of *Betula papyrifera.*

Natural Regeneration: Establishes itself from seed (Hardy BBT 1989) and suckers (Tannas 1997). Seeds that disperse in late fall and winter have higher germination capacity than seeds that disperse early (Safford *et al.* 1990).
Germination: >60% germination following 30 days cold stratification with fresh seeds of subspecies *neoalaskensis* (Smreciu *et al.* 2002b). Seeds loose viability quickly.
Pre–treatments: Cold stratification of 60-90 days (Nichols 1934). The presence of light increases the success rate of seed germination (Brunvatne 1998, Young and Young 1992). If tested under light at 20 to 25°C, no pre–treatment necessary for germination (Brinkman 1974).
Direct Seeding: 0.06% emergence the first year to 0.09% by year 4 with resulting robust seedlings. Best germination occurs on mineral soil under 45% sunlight (Safford *et al.* 1990).
Seed Rate: 200 seeds/m² results approx. 1 plant/m².
Vegetative Propagation: Reproduces from suckers (Uchytil 1991) and by regeneration from stump base and root collar. Six to eight inch long nodal cuttings with a long shallow wound may root if treated with 2000-8000 ppm IBA-solution before planting in a peat:sand medium (Dirr and Heuser 1987). Paper birch can also be propagated by grafting and layering (Babb 1959).
Micro–propagation: Shoot tip culture, extraction of axillary bud from young stem segments (Dirr and Heuser 1987).

Aboriginal/Food Uses

Food: The inner bark can be eaten as a sweet treat and starvation food; leaves, inner bark and root inner bark can be boiled to make a beverage; sap can be drunk or boiled down to make syrup.

Medicinal: Leaves can be used as wasp sting plaster; birch bark can be boiled and used in a decoction to enhance fertility; bark can be applied as a poultice for aching bones; powdery outer layer can be sprinkled on a sprained ankle; a sleeve of bark can become a cast for an arm or leg; a piece of sweet bark can relieve teething; the bark, as part of a compound decoction, can be drunk to treat tuberculosis and other lung problems; the reddish inner bark tea can be used as a gargle, for sore throats and colds; buds mixed with lard makes an ointment for treating skin sores and infections; roots can be used in a decoction to relieve menstrual cramps.

Other: Sheets of bark can be made into baskets, bowls, canoes, tepee covers, writing/drawing materials, weaving shuttles, artwork, sleds, snowshoe frames, canoe paddle, arrows, drum frames, handles, ceremonial rattles and kindling; inner bark can be made into yellow-red dye; birch branches are used to make sweat lodge frames.

Wildlife/Forage Usage

Wildlife: Paper birch is browsed by moose and white-tailed deer and is an important component of their diet. Snowshoe hares feed on saplings and porcupines eat inner bark. Small mammals (voles and shrews) and birds feed on catkins, seeds (redpoll, pine siskin, and chickadee), and buds. Sapsuckers favour paper birch sap leading to use by hummingbirds and squirrels. Birch stands also provide habitat for all types of wildlife (Uchytil 1991). Ruffed grouse eat male catkins and buds (Safford *et al.* 1990).

Livestock: Moderately palatable and used by livestock mostly in winter and spring (Tannas 1997).

Grazing Response: tolerant of moderate to heavy grazing (Uchytil 1991).

Male catkin of *Betula papyrifera.*

Reclamation Potential

This fast growing aggressive pioneer species rapidly colonizes open sites following disturbances (wildfire, wind throw, avalanche) and is recommended as an early successional species (Tannas 1997). Paper birch is a prime hardwood species for revegetation of disturbed sites. The litter formed by this species contributes to the nutrient content of the forest floor (enriched with calcium, potassium, magnesium, phosphorus and boron) (Safford *et al.* 1990). *Betula papyrifera* produces an abundance of lightweight seeds that are easily dispersed by wind, and in the case of a wildfire, the fire-prepared seedbeds make for rapid seedling establishment. However, paper birch seedlings have poor survival and dieback in the first 5 years after major disturbances (e.g., mining). After only 1 generation, it will be replaced by shade tolerant conifers or northern hardwoods (Uchytil 1991).

Commercial Resources

Availability: Available commercially in various stages (seed, saplings) at Alberta and Saskatchewan nurseries.

Cultivars: At least two cultivars are available in the horticultural trade but these are unsuitable for revegetation use.

Uses: Birch wood is valued in the fabrication of veneer, plywood and pulpwood. The treetops are used for interior decorating, and the branches are used for decorative furniture, baskets, wreaths, birdcages and other decorative purposes. The essential oil is used in aromatherapy. Birch bark contains betulin, an antiviral drug against AIDS virus and betulinic acid against melanoma and brain tumours (Marles *et al.* 2000).

Notes

Betula papyrifera is short-lived. It ceases to grow in height at 60-70 years old. Most trees do not live more than 140 years. Because of their canopy's high moisture content and their lush understory, paper birch stands are one of the least flammable forest types (Uchytil 1991). Although Hardy BBT (1989) indicates that paper birch is deep rooted, Safford et al. (1990) found that their root network is mostly found in the top 60 cm of soil and does not form taproots.

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Line Diagram: John Maywood, used by permission of Bruce Peel Special Collections, University of Alberta.

Scientific Name: Family: *Betulaceae*

Alnus incana ssp. *tenuifolia* Nutt. Breitung

Common Names: river alder, thinleaf alder, speckled alder

Plant Description

Large shrub or small tree 2-8 m tall; bark thin and smooth marked with orange lenticels; leaves oval to broadly ovate, doubly serrate 4-10 cm long and slightly pubescent beneath; flowers in catkins.
Fruit: Short-stalked seed cones, 1-2 cm long
Seed: Samaras, 2-3.5 mm, flat, ovoid, wingless, brown, rough.

Habitat and Distribution

Found in riparian, bog, and nutrient-rich swamp communities, on riverbanks and lakeshores. Low shade tolerance, tolerant of flooding (Hardy BBT 1989).
Soil: The pH range is 5.5-7. Adapted to a wide range of soil textures, however is most common in poorly drained soils (Healy and Gill 1974)
Distribution: Widespread across Alberta, frequent in all regions except the mixed grass prairie (Tannas 1997). Alas, Yuk, to s Calif, Colo, e to Man.

Phenology

Flowering from April-June. Fruits ripen late August through September. Seeds dispersed by wind during fall and winter (Healy and Gill 1974).

Pollination

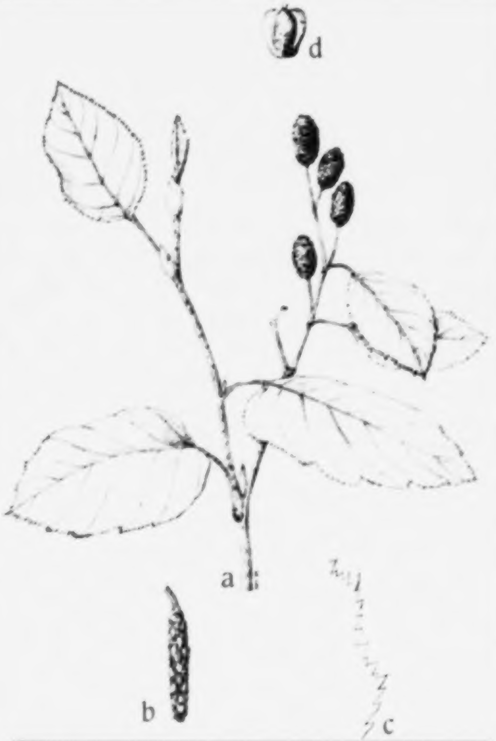
Pollen spread by wind (Healy and Gill 1974).

Genetics

2n=28

Symbiosis

Arbuscular mycorrhizal symbiosis is critical for successful establishment of *A. incana* (Monzón and Azcón 2001). *Frankia* (nitrogen fixing soil bacteria) inoculation significantly increases biomass production (Hendrickson *et al.* 1993).



Alnus incanca ssp. _tenuifolia_ **a. branchlet bearing seed cones. b. pollen cone.c. leaf serations. d. seed.**

Seed Processing

Collection: Catkins are easily stripped from branches, often while somewhat immature, and left to air dry
Seed Weight: 0.382-0.627 g/1000 seeds (0.490 avg)

Harvest Dates: Harvest when the bracts start to separate on the earliest cones, generally in late August

Cleaning: Air dry at ambient air temperature for several weeks. Crush material or remove large chaff and crush remaining material. Sieve to remove seeds from chaff using appropriate size screens (1.20 or 1.40 mm). Small chaff and dust can be removed by winnowing.

Storage: Store in sealed containers at 2-5°C (Young and Young 1992)

Longevity: When refrigerated in sealed containers (1-3°C), seeds can be stored and viable for up to 10 years (Healy and Gill 1974).

Propagation

Natural Regeneration: Reproduction occurs mainly through sprouting from root crown but also through layers, suckers, and underground stems (Van Deelen 1991) as well as from seed (Healy and Gill 1974).

Germination: 30% in 30 days from fresh or 1 year old seed from northeastern Alberta.

Pre–treatments: Cold stratification of 30-90 days (Nichols 1934). King (1980) reports that fresh seeds may not need stratification, however, stored seeds with less than 10% moisture content may need cold stratification. *A. incana* exhibits increased growth vigour in full sunlight and better seed germination in saturated soil (Healy and Gill 1974).

Direct Seeding: No emergence within 5 years when seeded in reclaimed sites in northeastern Alberta. Successful in Pennsylvania: fall-collected seed was sown the following February and March in cool, moist sites close to a stream (Healy and Gill 1974).

Seeding Rate: 1/8 pound (0.056 kg) per 100 square feet (9.290 m^2) (Healy and Gill 1974).

Vegetative propagation: By 1 foot (0.3048 m) hardwood cuttings (Babb 1959).

Aboriginal/Food Uses

Medicinal: Inner bark used to wash sore eyes, bark used as laxative.

Other: Boiled bark and stem pieces are used to make red-brown dye for hides, and alder wood is used to make carved tools and implements.

Wildlife/Forage Uses

Wildlife: Moose, muskrats, beavers, cottontail rabbits and snowshoe hares feed on branches and foliage. Songbirds feed on seeds; woodcock and grouse eat buds and catkins and use alder for cover. Commonly used by beavers for dam construction (Healy and Gill 1974).

Commercial Resources

Availability: Available as seed and/or plants at Alberta nurseries

Uses: Tree tops are used for interior decorating and branches are used for baskets, wreaths, birdcages, and decorative furniture (Marles *et al.* 2000). Trees have been cut for poles (Hardy BBT 1989).

Reclamation Role

Exposure of mineral soil creates optimal seedbeds and accelerates alder's invasion of a site (Van Deelen 1991). River alder fixes atmospheric nitrogen, which in turn improves fertility and physical properties of soil (Hardy BBT 1989).

Notes

River alder sprouts rapidly from persistent root crowns following mild fires. Severe fires delay regeneration (Van Deelen 1991).

Photo Credits

Line Diagram – John Maywood, used by permission of Bruce Peel Special Collections, University of Alberta

Scientific Name: **Family: *Betulaceae***
Alnus viridis ssp. *crispa* (Ait.) Turrill
Common Names: green alder, sitka alder, mountain alder wavy-leaf alder, slide alder

Plant Description

Shrub, 1-5 m tall; fuzzy branches with pale lenticels, sticky when young; alternate leaves are irregularly toothed, ovoid, leathery, 2-8 cm long; inflorescence in catkins, 1-1.5 cm, male pendulous, female woody and erect.
Fruit: Short-stalked seed cones, 1-2 cm long.
Seed: Samaras, smooth to rough texture, 3 mm x 1.5 mm (2-3 mm with wings), flat, oblong, light brown with papery translucent wings.

Habitat and Distribution

Habitat: Sand hills, open forests and edges of wetlands and streams. Semi-shade tolerant, but cannot grow with a dense overstory (Matthews 1992, Hardy BBT 1989).
Seral Stage: Pioneer species, invading terraces above floodplains. Responds well to fire and resulting bare mineral soils (Hardy BBT 1989).
Soils: Coarse textures ranging from sandy to gravely/rocky; morainal deposits (Hardy BBT 1989).
Distribution: Boreal forest, aspen parkland, and Rocky Mountains foothills in Alberta. Alas, Yk, Nfld to nCalif, Ida, Mont, cSask, Minn, Gr Lakes, NC.

Phenology

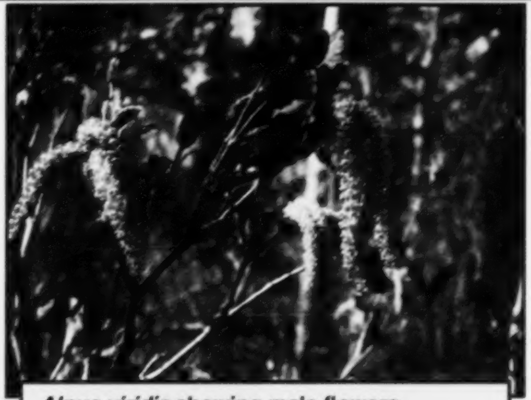
Female catkins open at the same time as leaves in spring. Flowers in May and June, fruit matures in July, seeds ripen from late August to November.

Pollination

Wind pollinated (Rook 2006a).

Genetics

2n=28



Alnus viridis **showing male flowers immediately after pollen shed. Brown cones are those that shed seeds last year and young female cones can be seen just opening.**

Symbiosis

Green alder is ectomycorrhizal (Hagerman and Durall 2004). Inoculation of *Frankia* is rarely necessary as most soils contain abundant populations (Hendrickson *et al.* 1993). A single fungus is not associated with *Alnus*, but a seral succession follows both plant succession as well as aging of the dominant plants of a community (Sampo *et al.* 1997).

Seed Processing

Collection: Female catkins are easily stripped or snipped from low branches, or by bending branches to bring catkins within reach.
Seed Weight: 0.135-0.222 g/1000 seeds (0.2 avg)
Harvest Dates: Late August
Cleaning: Air-dry fruits in paper at 15-25°C. Crush material or remove large chaff and crush remaining material. Sieve to remove seeds from woody catkins using appropriate size screens. Small chaff and dust can be removed by winnowing.

Storage: Store in sealed containers at cool temperatures (2-5°C) (Young and Young 1992).
Longevity: Seeds are viable for at least 2 years when stored dry at room temperature.

Propagation
Natural Regeneration: Sprouts from root crown *in situ* (Rook 2006a).
Germination: 10-20% germination in the first month with seeds from northeastern Alberta.
Pre–treatments: Cold stratification of 30 days. Nichols (1934) suggests 60-90 days cold stratification.
Vegetative Propagation: Propagates by layering (Rook 2006a)

Seedling of *Alnus viridis* grown from directly sown seeds.

Aboriginal/Food Uses
Food: Dry alder wood is burned to smoke salmon.
Medicinal: Stems can be boiled to treat upset stomachs. Roots can be used in a decoction to treat menstrual cramps. Inner bark decoction can be used as a wash for sore eyes and bark can be taken as a laxative.
Other: Bark and stem pieces, once chopped and boiled, make a red-brown dye for hides. Carved tools and implements can be made out of alder wood. Peat moss burned with rotten alder wood can be used to smoke hides during tanning. Also, rotten wood can be burned to repel mosquitoes.

Wildlife/Forage Usage
Wildlife: Heavily browsed by moose and caribou in some areas; consumed in small quantities by deer; muskrat, beaver, cottontail. Snowshoe hares feed on twigs and foliage, birds feed on catkins, seeds, and buds; winter forage for white-tailed ptarmigan (Matthews 1992).
Livestock: May be important as secondary forage for cattle (Matthews 1992).
Grazing Response: Resistant to grazing, regenerates from rhizomes and seed (Hardy BBT 1989)

Reclamation Potential
Increases soil organic matter through nitrogen-fixation. Early serial species that invades disturbed site. Provides protection from wind and sun to young spruce trees (Hardy BBT 1989). *Alnus viridis* also increases above ground biomass accumulation in *Pinus banksiana* stands (Vogel and Gower 1998).

Commercial Resources
Availability: Several Alberta nurseries carry propagules.

Uses: The treetops are used for interior decorating (the trunks and branches are used to produce natural-looking, semi–artificial trees with silk leaves), and the branches are used for baskets, wreaths, birdcages and decorative furniture (Marles *et al.* 2000).

Photo Credits
Photos: Wild Rose Consulting, Inc

Scientific Name: **Family:** *Cornaceae*

Cornus stolonifera Michx.

Common Names: red-osier dogwood, dogwood, red willow

Cornus stolonifera **flowering branch**

Soil: Found on well drained to poorly drained soils. Most successful on free draining soils with an adequate moisture availability. Tolerant of a wide range of pH values (3.2-8.0), preference for nutrient rich sites (Smithberg 1974).

Distribution: Widespread across Alberta (boreal forest, aspen parkland and Rocky Mountains). Alas to James Bay, s to Calif, Wva, Pa.

Phenology

Flowers April to August (September). Fruit ripens from mid-July to mid-October in northeastern Alberta.

Pollination

Cross-pollinated by *Andrena, Apis* and *Bombus* spp. (Gunatilleke and Gunatilleke 1984), some beetles, flies and butterflies (Eyde 1988).

Plant Description

Deciduous, perennial, upright shrub, 1-3 m high, with spreading rhizomes; lower branches often prostrate; deep-red (green-purple) pubescent twigs; oval to ovate-lanceolate leaves 2-6 cm long, glaucous beneath; flat-topped terminal clusters of many white flowers with 2-3 mm long petals.

Fruit: white round drupe, succulent, 6-8 mm in diam (Banerjee *et al.* 2001).

Seed: 3.5-5 mm oval stone, 1-2 embryos, grey to deep brown with pale striations, smooth.

Habitat

Common in moist woods, ponds, riverbanks, thickets, clearings and coulees throughout the Canadian prairies. Also, found in river flood plains. Shade and flood tolerant

Seral Stage: early to late seral species.

Cornus stolonifera **berries.**

Genetics

2n=22

Symbiosis

Endomycorrhizal inoculation with *Glomus fasciculatum* and *Glomus macrocarpum* during propagation significantly increases the growth of the plant during later stages of development (Verkade et al. 1988).

Seed Processing

Collection: Berries are easily shaken or picked from taller bushes or trees. Large clumps make collection particularly easy. Seeds should not be picked from isolated plants to avoid the risk of self-sterile seed or empty fruit collection (Young and Young 1992).

Seed Weight: 24.7-28.6 g/1000 seeds (27.0 avg).

Fruit/Seed Volume: 2050-2890 fruit/L (2460 avg), 2460 seeds/L fruit.

Fruit/Seed Weight: 4520-5470 fruit/kg (4900 avg), 4900 seeds/kg fruit.

Average Seeds/fruit: 1 seed/fruit (occasionally with 2 embryos).

Harvest Dates: Collect in late July to late August in northeastern Alberta. Harvest as soon as fruits are ripe (snowy white to blue tinged) (Banerjee *et al.* 2001).

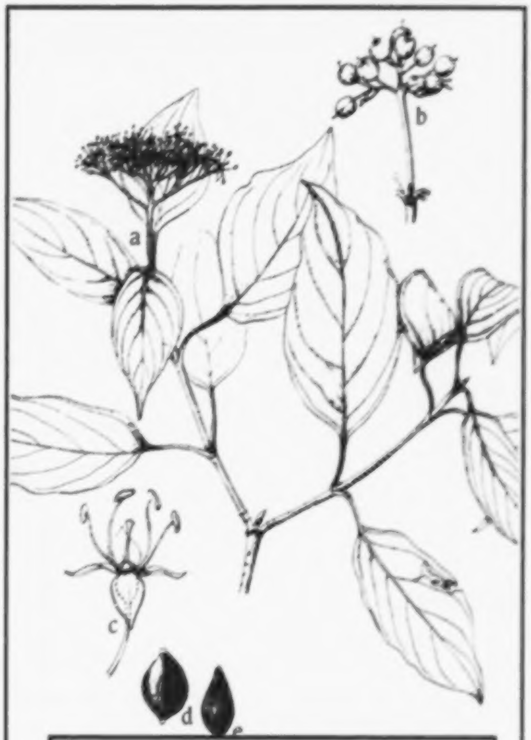
Cleaning: Mash fruit in a sieve (1.40 mm works well). A blender with taped blades may also be used to macerate the fruit. Suspend residue in water allowing seeds to settle. Decant water and chaff. Repeat suspension and decanting until only seeds remain. Allow seed to dry at room temperature.

Storage: Store dry in sealed containers at cool temperatures (3-5°C) (Young and Young 1992)

Longevity: 4 to 8 years when stored in sealed glass containers at 1-3°C (Smithberg 1974; Harrington et al 1999).

Propagation

Natural Regeneration: Both by seed and vegetative means (new shoots from roots and prostrate branches) (Crane 1989). Will produce stolons in very moist. Reproduces from sprouts and root shoots (Smithberg 1974, Hardy BBT 1989).



Cornus stolonifera **a. branch with inflorescence. b. fruit. c. individual flower. d-e. seeds.**

Germination: 11% in 30 days, 1 or 2 year old seeds from northeastern Alberta.

Pre-treatments: McTavish and Shopik (1983) recommend 60-90 days cold stratification at 1°C. Nichols (1934) – 2 months cold stratification at 2-4°C. Young and Young (1992) – 3–5 months cold stratification at 3–5°C. Seeds may be stored at cold temperatures for a month and then stratified for a month using light dark cycles during incubation Acharya *et al.* (1991).

Direct seeding: Less than 1% emergence from seeds. Sowing intact fruit results in numerous robust seedlings (> 7% emergence for fall sown fruit). Fruit should be sown immediately after harvest. If using frozen stored berries, fall sowing resulted in slightly better emergence than spring sowing. Young seedlings are drought intolerant.

Seeding Rate: 100 seeds/m² and 50 fruits/m² to obtain 1-4 plants/m².

Vegetative Propagation: Hardwood pole cuttings placed directly are often successful (Smreciu and Barron 1997). Can establish from softwood stem and root cuttings in high moisture conditions (Hartmann *et al* 1990, Tannas 1997). Eighty percent rooting using hardwood cutting with seradix #2 treatment in a mixture of 1:1:1 peat/sand/reground styrofoam chips with 16 °C bench heat (McTavish and Shopik 1983). Smithberg (1974) also reports that dogwood can be propagated by layering.

Aboriginal/Food Uses

Food: Some tribes mix the berries with other sweeter berries.

Medicinal: Tea made from roots is used to treat dizziness; tea from stems is used to relieve chest trouble, as an emetic, or for coughs and fevers. A decoction made from the bark is used as a laxative. Peeled bark mixed with other plants and boiled can treat sore eyes. A wash, made of fruit or stem pith, is used to treat snow blindness or cataracts. A decoction made from ripe fruit can treat tuberculosis. A decoction made of roots mixed with other herbs is used to treat diarrhea in children.

Other: Thicker stems can be used to make ribs for spruce bark canoes (Marles *et al.* 2000).

Wildlife/Forage Uses

Wildlife: One of the most valuable browse species in Alberta (Tannas 1997) especially for moose. Used for food and cover by white-tailed deer, mule deer (heavily used in summer), elk, mountain goats, cottontail rabbits, snowshoe hares, and numerous birds (Crane 1989) including ruffed grouse (Hardy BBT 1989). Berries are also eaten by black bear and beaver (Smithberg 1974).

Livestock: Leaves are relatively unpalatable to livestock however, the young sprouts are palatable. Livestock browse red-osier dogwood however it is not a preferred species (Crane 1989).

Grazing Response: Resistant to heavy browsing (Tannas 1997). Extensive deer browsing increased branching and fruit/seed production on reclaimed sites (Smreciu and Barron 1997).

Seedling of *Cornus stolonifera*.

Reclamation Role

Cornus stolonifera is a prolific seed producer (Smreciu and Barron 1997).

Useful in stabilization of eroding stream banks. Rooting from cuttings may accelerate this stabilization.

High tolerance for oil and high salinity oil sands tailings water (Renault *et al.* 1999, Hardy BBT 1989).

Grows successfully (from container seedlings) on various reclamation sites (Fung 1990, Fedkenheur *et al.*1980, Smreciu and Barron 1997).

Rapid growth and easy establishment of seedlings and transplants.

Dogwood has a high tolerance to sodium and sulphate enriched consolidated tailings water (Renault *et al.* 1998).

Commercial Resources

Availability: Produced commercially by several Alberta and Saskatchewan nurseries.

Cultivars: Numerous horticultural cultivars are available but these are not suitable for reclamation.

Uses: As an ornamental shrub, and dried or preserved floral products. Common for windbreaks and border plantings (Smithberg 1974).

Notes

The red-osier dogwood is able to tolerate extremely cold temperatures, and flooding. It is a semi fire-tolerant, seed banking species that generally increases in abundance following a fire (Crane 1989).

The Integrated Taxonomic Information System name for *Cornus stolonifera* is *Cornus sericea* ssp. *sericea*. The name *Cornus stolonifera* is used to be consistent with the ANHIC elements list.

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Line Diagram: John Maywood, used by permission of Bruce Peel Special Collections, University of Alberta.

Scientific Name: **Family:** *Ericaceae*

Ledum groenlandicum Oeder

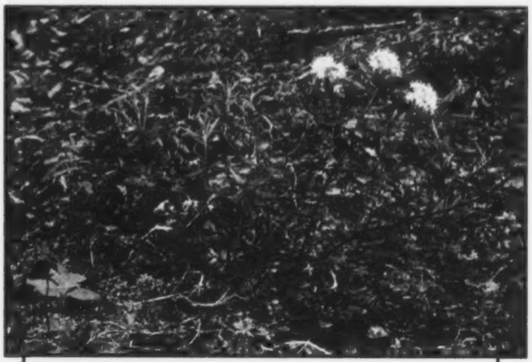
Common Names: Labrador tea, bog Labrador tea, rusty Labrador-tea, St. James' tea, marsh tea, swamp tea, Hudson's Bay tea

Plant Description

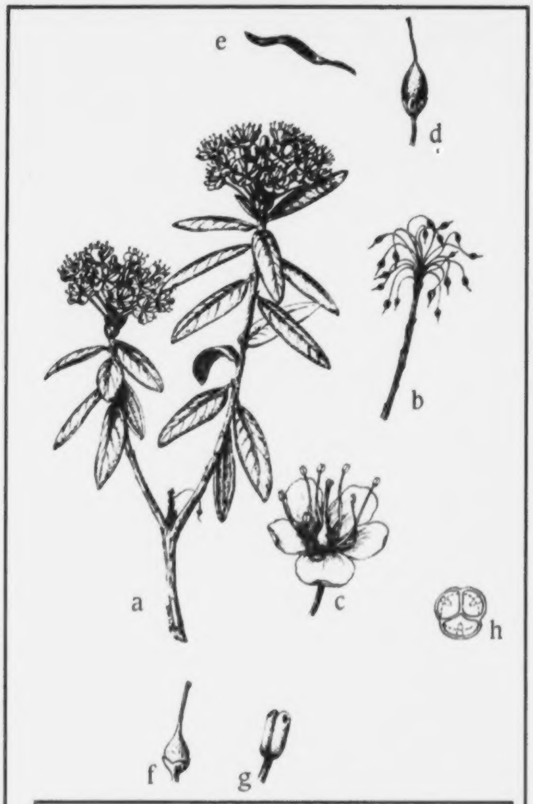
Perennial, erect, aromatic shrub, 30-80 cm high, rhizomatous, 15-48 cm deep (Viereck and Schandelmeier 1980, Flinn and Wein 1977), soil and moisture characteristics greatly influence length and depth of rhizomes (Coladonato 1993); leaves alternate, oblong to elliptic evergreen, 1-5 cm long, deep green above and densely rusty-tomentose beneath; terminal umbel of white flowers, each 5-8 mm long.

Fruit: Puberulent, oval to oblong capsules 5-7 mm long, in clusters.

Seed: 2-3 mm long, needle-shaped, straw-coloured, central embryo darker, striate to wavy texture.



Ledum groenlandicum **plant in flower.**



Ledum groenlandicum **a. flowering branch b. seed head c. flower d. individual capsule e. seed f. stigma g. anther h. pollen.**

Habitat and Distribution

Commonly found in acidic and moist organic substrates such as bogs, muskegs, swamps and wet coniferous woods.

Soil: Tolerant of acidic and infertile soils (Tannas 1997).

Distribution: Found in northern Alberta, Rocky Mountains, southwestern Alberta and west–central Alberta. Widespread in the northern parts of the circumpolar boreal forest, sub arctic and arctic tundra. Alas, Yuk, n Que, Nfld, to Ore, BC, Gr Lakes, Pa, NJ; Greenland.

Phenology

Flowers late May to early June. Fruits ripen late August to fall (Coladonato 1993).

Pollination

Self and cross pollinated by a variety of insects including, Apis, Bombus and Andrena in particular (Reader 1977). Possibly wind pollinated (Knuth 1909).

Ledum groenlandicum **inflorescence.**

Genetics

2n=26

Symbiosis

Forms ericoid mycorrhiza with a diverse assemblage of fungal endophytes (e.g., *Hymenoscyphus ericae*) (Hambleton *et al.* 1999, Massicotte *et al.* 2005). *L. groenlandicum* is a host of the root endophytic fungus *Phialocephala fotinii* (Addy *et al.* 2000).

Seed Processing

Collection: Capsules are easily plucked from the low bushes.

Seed Weight: 0.01-0.04 g/1000 seeds (0.02 avg).

Harvest Dates: Late August.

Cleaning: Air-dry fruits. Remove large chaff and crush remaining material. Sieve to remove seeds from chaff using appropriate size screens (0.85 mm). Small chaff and dust can be removed by winnowing. If capsules are intact merely open capsules and empty seeds; sieve or winnow to remove chaff and dust.

Storage: store dry (Karlin and Bliss 1983).

Longevity: usually does not exceed 1 year (Karlin and Bliss 1983).

Propagation

Germination: Seed germination decreases with age. Fresh seeds: 58% in 25 days. Stored seeds: 16 % after 1 year; up to 1 year old (Karlin and Bliss 1983). Smreciu *et al.* found similar results in northeastern Alberta populations: 29% in 30 days with fresh or 1 year old seeds but not 2 year old seeds.

Pre–treatments: 4 weeks cold stratification (Nichols 1954). Karlin and Bliss (1983) concluded that germination occurred without cold stratification. Relatively high constant temperatures (15-19°C) are required for germination. Germination rates increase in the presence of light. Germination and establishment in water-saturated substrates can occur, however seedlings will most likely be short-lived because of the small-size and slow growth rate of the seedlings (Karlin and Bliss 1983).

Direct Seeding: No significant emergence observed, only small seedlings observed after 5 years on reclaimed oil sands sites in northeastern Alberta.

Vegetative propagation: Rhizome division may be possible. Cuttings (taken in mid-December) root well (Dirr and Heuser 1987).

Aboriginal/Food Uses

Food: beverage tea.

Medicinal: the leaves (chewed or made into tea) can treat stomach flu, chills, pneumonia, headaches, diarrhea, heart ailments, arthritis, whooping cough, teething pain, kidney ailments, and relieve tension. Powdered leaves relieve burns and eczema. Leaf decoctions can be used as an eye–wash to relieve dry eyes. Boiled whole plants can treat chest pains and hair loss. Peeled root decoction is used to treat colds and clean out stomach.

Wildlife/Forage Uses

Wildlife: Leaves and twigs are browsed by caribou and moose. Provide cover for a wide range of small wildlife species (Coladonato 1993). Unpalatable to snowshoe hares and other rodents because of the presence of germacrone concentrations (known as a chemical defence) in the leaves and internodes of the plant (Reichardt *et al.* 1990).

Livestock: Unpalatable to livestock (Tannas 1997).

Grazing Response: Moderate tolerance to browsing (Tannas 1997).

Commercial Resources

Availability: Labrador tea is available commercially in plant form in Alberta, but not widely.

Uses: Essential oil for aromatherapy, ornamental shrub.

Reclamation Role

Naturally re–colonizes sites disturbed by logging, burning and mining (Coladonato 1993). Useful in revegetation of fertile soils (Tannas 1997).

Notes

Re-establishes itself rapidly following fire due in part to the high temperature requirements for germination (Karlin and Bliss 1983).

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Scientific Name: **Family:** *Rosaceae*

Prunus virginiana L.

Common Names: chokecherry, common chokecherry, and Virginia chokecherry

Plant Description

Perennial slender shrub or tree, 10 m high; reddish brown bark with inconspicuous lenticles; leaves alternate, simple, elliptical to egg-shaped, 5-10 cm, lighter beneath, smooth, toothed margins; racemes, 5-15 cm, terminal with white flowers, 4-10 mm across, 5 petals; widely branching roots.

Fruit: Glossy, red-purple drupe, astringent, spherical, 1-2 cm diameter.

Seed: 5 x 7 mm, oval, rough texture, brown, one margin ridged, and other scored. Large seeds tend to occur on upland sites while more numerous smaller seeds can be found in riparian areas (Parciak 2002a; Parciak 2002b).

Habitat and Distribution

Found in a variety of forested areas as well as thickets, ravines, shores and sand dunes, and along fence lines and roadsides. Semi-tolerant to shade.

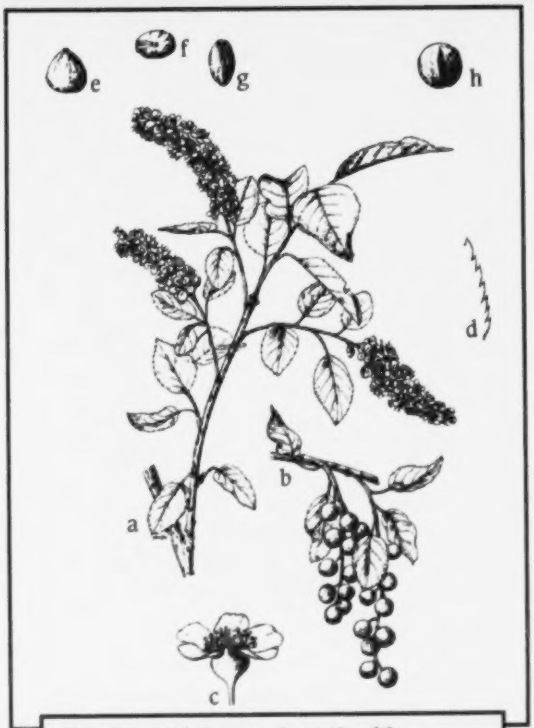
Seral Stage: A climax indicator species, chokecherry in pure stands is relatively stable.

Soils: Most productive on rich, moist loamy soils, but will grow on a wide variety of soils and moisture regimes. Optimum soil pH 6.0-8.0 (Vilkitis 1974). It tolerates moderately acidic (pH 5.0), moderately basic, and weakly saline soils (McMurray 1987). Intolerant to poor drainage and prolonged flooding (Johnson 2000).

Distribution: Widespread across Alberta: Rocky Mountains, foothills prairie, and parkland. BC to Nfld south to Calif, NM, NC, Okla, Ark, Tenn.

Phenology

Leaves open in May with flowers a few weeks later. Fruit matures in late July through September with seeds ripening at the same time.



***Prunus virginiana*. a. branch with inflorescences. b. fruit clumps. c. individual flower. d. leaf serrations. e-g. seeds. h. pollen.**

Pollination

Pollinated by bees, butterflies and other insects (Young and Young 1992).

Symbiosis

None (Pashke et al. 2003).

Genetics

2n = 16, 32

Seed Processing

Collection: Easy to strip berries from branches in clusters.

Seed Weight: 52.6 – 75.0 g/1000 seeds (64.7 avg).

Fruit/Seed Volume: 1000-1520 fruit/L (1200 avg), 1200 seeds/L fruit

Fruit/Seed Weight: 1490-2510 fruit/kg (2090 avg), 2090 seeds/L fruit

Average Seeds/fruit: 1 seed/fruit

Harvest Dates: Late August. Collect when fully mature to facilitate cleaning and enhance germination success. Ripe fruit are red-purple in colour (Banerjee *et al.* 2001).

Cleaning: Mash fruits by hand or use a potato masher, apple-saucer, or ricer, or run through a hand meat grinder. Alternatively, use a food processor on low speed with blunt mashing blade (not a sharp blade) or use a blender with blades covered by plastic tubing or duct tape. Suspend residue in water and mix; allow seeds to settle and decant water with floating and suspended larger chaff. Repeat this step until seeds are clean; sieve and place seeds on paper toweling or cloths to dry. Dry at room temperature or up to 25°C preferably over a moving air stream.

Storage: Store dry in containers at cool temperatures.

Longevity: Clean seeds, stored just below surface dry conditions and sealed in containers at 1°C can remain viable for up to 5 years (Rose *et al.* 1998).

Propagation

Natural Regeneration: From seed and by rhizomes or basal sprouts (McMurray 1987, Pashke *et al.* 2003).

Germination: No significant germination (<10%) in vitro regardless of treatment.

Pre–treatments: Hudson and Carlson (1998) suggest scarifying for 15-90 minutes, followed by 2 months warm stratification, and 4 months cold stratification. There is evidence that ingestion by wild black bears significantly improves germination percentages because of the acid and mechanical scarification of seeds in the digestive tract (Auger *et al.* 2002). Lockley (1980) had successful germination after 16-24 weeks cold stratification (3°C) followed by a 21-27°C-temperature regime. Dirr and Heuser (1987) obtained 52% germination after 6 months cold stratification.

***Prunus virginiana* seedlings grown from berries grown on a revegetated site.**

Direct Seeding: Less than 1% emergence, however, vigorous seedlings on oil sands reclamation sites in northeastern Alberta.

Fruit Sowing: Emergence of vigorous seedlings, 3% by year 4 (fall sown). Optimal conditions for nursery production are moist sand: peat, moist vermiculite, or 1:1 peat: perlite, and bright light favours growth and development (St-Pierre 1993).

Sowing Spacing: 0.2-0.3 m (Paschke *et al.* 2003).

Seeding Rate: 100 seeds/m², 50 fruits/m² to obtain 1-2 plants/m².

Vegetative propagation: Rooted cuttings can be successful. Terminal and basal cuttings harvested in June have been rooted using 8000 ppm IBA-talc, sand and mist (Dirr and Heuser 1987). Propagation is also possible with 15 cm long semi-hardwood cuttings, crown division, grafting and through micro propagation (tissue culture) (St-Pierre 1993). Babb (1959) reports successful propagation by suckers and budding.

Aboriginal Uses

Food: Can be eaten fresh, frozen, or cooked, added to pemmican once dried, fermented to make wine, used for jellies, syrups, and sauces with meat and stews. Still collected in the wild in large quantities.
Medicinal: Boiling the leaves, stems, bark, and roots makes a tea useful for treating colds, fever, pneumonia, to clear the throat, and to treat high blood pressure and heart problems. Boiled bark can be used as an emetic drink. Boiled roots can make a tea to treat flu or be part of a medicine to treat diarrhea in children.

Wildlife/Forage Usage

Wildlife: Browsed by elk, bear, coyotes, pronghorn, deer, moose, and bighorn sheep (Johnson 2000). Flowers are an important source of nectar for butterflies, honeybees, and ants (Crowder *et al.* 2004). A variety of bird species (ruffed, blue, and sharp-tailed grouse, quail, prairie chicken, ring-necked pheasant, magpie), cottontail rabbits, chipmunk, black bear and mule deer feed on the berries. White-tailed deer use the bark for antler rubs (Sykes 2000). Provides important cover and habitat for many bird species, small mammals, large mammals and livestock (Johnson 2000).
Livestock: Occasionally poisonous to sheep and cattle. Moderately palatable to livestock.
Grazing Response: Tolerates moderate grazing. Will resprout from root crown.

Reclamation Potential

Chokecherry provides watershed protection and wildlife habitat (McMurray 1987). It has a high suitability for erosion control and soil stability because it can form thickets and spread by rhizomes. Chokecherry is well adapted to disturbed sites and is a fast-growing very competitive shrub (St-Pierre 1993) that has proven to be somewhat salt tolerance (Johnson 2000). Smreciu and Barron (1997) found that plant salvage was extremely successful if plants were potted and maintained in a nursery for one growing season and placed when dormant.

Commercial Resources

Harvest Methods: Handpicking, using a berry rake, or a small power vibrator, mechanical harvesters (a pull type harvester or a self-propelled harvester) (St–Pierre 1993).
Availability: Available from a wide variety of sources. Both seed and seedlings available.
Cultivars: Numerous cultivars are available for fruit production in Manitoba and Alberta (St-Pierre 1993) but these are not suitable for use in reclamation.
Uses: Established market for jellies, wines, syrup, cough syrups, and ornamental shrub. Also used as windbreakers in the prairie, plains, and western mountains (Johnson 2000).

Notes

Chokecherry is well adapted to fire disturbance. Because of vigorous sprouting from surviving root crowns and rhizomes, chokecherries have a moderately rapid recovery and density increases following a fire. They are susceptible to attack by the fungus *Plowrightia stansburiana* that can limit their growth (McMurray 1987). Due to the production of hydrocyanic acid formed only after disruption of the plant cell (mechanical injury or a sudden change in temperature), the leaves, bark, stem, and stone of chokecherry become toxic. Only the meaty flesh of the fruit is not toxic (Crowder *et al.* 2004).

Photo credits

Photo: Wild Rose Consulting, Inc.
Line Diagram: John Maywood, used by permission of Bruce Peel Special Collections, University of Alberta.

Scientific Name: **Family:** *Rosaceae*

Rosa acicularis Lindl

Common Names: prickly rose, bristly rose

Plant Description

Low bushy shrub, 0.5-1.5 m high, perennial, rhizomatous, roots 20-30 cm deep (Viereck and Schandelmeier 1980); stems stout, densely covered with straight slender thorns; compound leaves of 3-7 pubescent leaflets, each 3-4 cm long sharply double-toothed; single pink flowers 5-7 cm across.

Fruit: Fleshy, red hypanthium, ovoid to pear-shaped or spherical; numerous achenes.

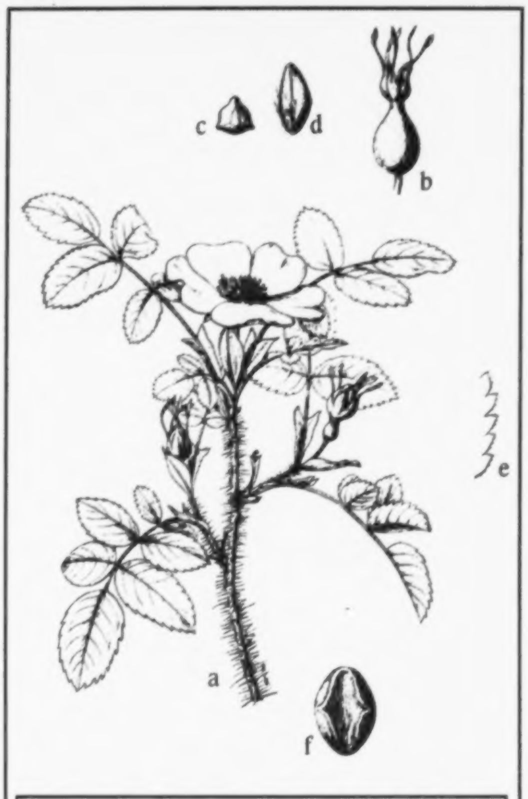
Seed: 3-5 mm, straw to golden yellow seeds, angular/planar pear-shaped, smooth to rough textured.

Habitat and Distribution

Common in open woods and fields throughout the prairies, banks, roadsides and thickets. Common in the shaded (shade tolerance) undergrowth of mixed woods and deciduous forests (Hardy BBT 1989).

Soil: Adapted to a wide range of soil moisture and texture conditions. High acid tolerance, flood tolerance and low nutrient soil tolerance (Hardy BBT 1989).

Rosa acicularis **flower; the floral emblem of Alberta.**



Rosa acicularis **a. flowering branch b. fruit c.d. seeds e. leaf serrations f. pollen**

Distribution

Widespread and common across North America, throughout the boreal forest region. Alas to Huds Bay, s to BC and Vt.

Phenology

Flowers late May to late June. Fruits ripen from July to August (Crane 1990).

Pollination

Pollinated by bees, butterflies and other insects (Fern 1997).

Genetics

2n=42, 56

Seed Processing

Collection: Fruit can be easily pulled from branches.
Seed Weight: 10–13 g/1000 seeds (11.8 avg.)
Fruit/Seed Volume: 380-528 fruit/L (458 avg.); 10 500 seeds/L fruit
Fruit/Seed Weight: 1120-1340 fruit/kg (1190 avg); 27 300 seeds/kg fruit
Average Seeds/fruit: 23 seeds/fruit
Harvest Dates: For greater germination, collect fruits when not fully ripe (King et al 1983). Collect when the hips are bright red or orange-red (Banerjee *et al.* 2001) – late August in northeastern Alberta.
Cleaning: Mash fruit in a sieve (1.40 mm works well). A blender with taped blades may also be used to macerate the fruit. Suspend residue in water allowing seeds to settle. Decant water and chaff. Repeat suspension and decanting until only seeds remain. Alternatively, a tomato de-seeder may be used, as achenes are approximately the same size. Allow seed to dry at room temperature over a moving air stream.
Storage: Store dry in sealed containers (Young and Young 1992).

Propagation

Natural Reproduction: By seed and from rhizomes (Hardy BBT 1989).
Germination: Field emergence is more successful than in vitro germination. Most seeds take 2 years to germinate – during the 1st growing season the seeds develop and mature, the next growing season provides the warm stratification period and the subsequent winter provides the cold stratification period – seeds germinate during the next spring shortly after snowmelt (Densmore and Zasada 1977).

Rosa acicularis **plant growing on the edge of a forest opening.**

Pre–treatments: Densmore and Zasada (1977) had success with 3 months warm stratification followed by 2 months cold stratification although Smreciu *et al.* (2007) reported no germination with the same treatment. King (1983) recommends 2 months warm stratification followed by 4 months cold stratification.
Direct Seeding: More than 1% emergence by sowing seeds on oil sands reclamation sites.
Fruit Sowing: Up to 5.3% emergence by year four.
Seeding Rate: 100 seeds/m² and 1.3 fruits/m² to obtain approximately 1 plant/m².
Vegetative Propagation: Spreads naturally by rhizomes; Also successfully grown from container seedlings (58-100%) (Fedkenheuer *et al.* 1980). If there is an easily accessible source, using root cuttings for large-scale propagation is feasible. Stem cuttings from dormant hardwood can also be successful if used with a hormone treatment, with coarse material for the rooting

media, and heavy watering to maintain high humidity levels (Hermesh and Cole 1983). Budding, suckers, layering, and grafting (Babb 1959). Softwood cuttings have been successful (Smreciu and Barron 1997, Fung 1984) especially when treated with 3000-5000ppm IBA-talc or K-IBA in water, placed in a peat/perlite medium and kept under mist (Dirr and Heuser 1987).

Aboriginal/Food Uses

Food: Once seeds are removed, rose hips are eaten fresh (high in vitamin C). They can be made into a jelly, beverage or syrup. Pink flower petals can be eaten as a treat.
Medicinal: Eaten raw, the fruit can prevent colds; rose petals can be used as a heart tonic and anti-sting; boiled branches can be used for menstrual relief; root decoction can treat diarrhea, cough, regulate menstruation, and used as eye drops to treat soreness; and the roots as part of a compound medicine can treat chest colds.

Wildlife/Forage Uses

Wildlife: Important food source for grouse, snowshoe hares, microtine rodents, and mule deer. In the fall the black bear, grizzly bear, rabbits and beavers eat the fruits, stems and foliage. Small mammals use the thickets for shelter and birds use them for nesting sites and protective cover (Crane 1990).
Livestock: Excellent summer browse for big game and livestock (Crane 1990).
Grazing Response: Resistant to heavy browsing. As a natural self-defence to over-utilization, with time woody growth become less palatable and spines become stiffer, at this point, plants are often avoided (Tannas 1997). Extensive deer browsing increases shoot production (Smreciu and Barron 1997).

Commercial Resources

Availability: Widely available from nurseries in Alberta and Saskatchewan.
Uses: Vitamin C, essential oil, floral arrangements and jams.

Reclamation Role

Rosa acicularis is a prolific seed producer in some years especially on open sites. Natural pioneer on disturbed sites where they increase soil stability and control erosion (Tannas 1997). Recommended for revegetation on moist to wet lands in Alaska and Alberta. Highly adapted to disturbance (King 1983). Adapted to a wide range of soil textures and moisture levels. Proven tolerance to drought on amended oil sand tailings and acidic situations in Alberta (Fedkenheuer *et al.* 1980). Spreads rapidly and have shown to recover rapidly following logging (Crane 1990).

Notes

Prickly rose is fire resistant. The deep rhizomes growing in mineral soil make it well adapted for sprouting after a fire (Crane 1990).

Photo Credits

Photos: Wild Rose Consulting, Inc.
Line Diagram: John Maywood, used by permission of Bruce Peel Special Collections, University of Alberta.

Scientific Name: **Family:** *Salicaceae*
Salix bebbiana Sarg.
Common Names: Bebb's willow, gray willow.

Plant Description

Deciduous, perennial, erect shrub or small tree 0.5-5 m high, dark reddish brown twisted branches; shallow dense roots; alternate leaves are elliptic to obovate, glaucus beneath, 3.5 to 9 cm long with margins entire to scalloped; male and female flowers in catkins (2-5 cm long) on separate plants.
Fruit: 6-9 mm long beaked capsules that split open along 2 sides.
Seed: 5-7 seeds per capsule that are surrounded by a coma of fine hairs (Zasada *et al.* 2003).

Habitat and Distribution

Common along shores, forest openings, in thickets and wetlands and also in the tundra. Shade intolerant, grows best in full sunlight (Hardy BBT 1989).

Distribution: Widespread across the northern hemisphere in temperate to arctic zones.

Phenology

Flowers from April to June. Fruit ripens in May through June.

Pollination

Bees are the main pollinators (Tesky 1992). *Salix* species are also pollinated by wind (Macdonald 1986).

Genetics

2n=38

Symbiosis

Host of ectomycorrhizal fungi (Hagerman and Durall 2004)

Seed Processing

Collection: Because *Salix* seeds are quickly dispersed by wind, branches may be cut just before seed dispersal and placed in water and kept in shed for easier seed collection. The seeds are then easily stripped from branches (Macdonald 1986).
Seed Weight: 0.1818g/1000 seeds (Young and Young 1992)
Harvest Dates: As soon as ripe (May-June), when the fruit changes from green to yellowish (Young and Young 1992).
Cleaning: Seed does not need to be separated from the capsules (Young and Young 1992).
Storage: Short viability limits storage of seed to 4-6 weeks (if seeds are kept moist and refrigerated in sealed containers) although reduction in germination is observed after only 10 days (King 1980).
Longevity: Up to 3 years if kept frozen at -10°C to –20°C (Densmore and Zasada 1983).

Propagation

Natural Regeneration: Establishes itself by basal stem sprouting, seed, suckers and root (Rawson 1974)
Germination: Fresh, summer-dispersed non–dormant seeds have the best germination percentages (95-100%) after 12 to 24 hours at 5°C to 25°C, up to 1 week. Moist substrate and light is required. (Densmore and Zasada 1983).
Pre–treatments: None required (King 1980). Dirr and Heuser (1987) recommend sowing seeds in moist ground immediately after collection.
Direct Seeding: Seeding the fruit was not successful in Northeastern Alberta
Seed Rate: 3-5 catkins/m^2
Vegetative propagation: Softwood cuttings, from tip or base, 20 cm, are more successful than hardwood (Holloway and Zasada 1979). The cuttings should be planted on sites with sufficient

moisture (Tesky 1992). Cuttings were a successful propagation method on wetland sites in the oil sands reclamation area in Fort McMurray: 10% survival of soft tip cutting the 1st year and 6% survival the 2nd year; and 21% survival of pole cutting the 1st year and 16% survived the 2nd year .

Aboriginal/Food Uses

Food: Wood can be burned to smoke meat. After boiling the branches twice (first water discarded) can be used to add flavour to home-brew.
Medicinal: Flowering branches can relieve diarrhea, and stomach aches; inner bark can bring relief to constipation; branches or roots can help sooth toothaches; roots can also relieve fatigue, and stop external bleeding. Prolonged therapy of pain relief by slow release of natural salicylates from willow bark
Other: Various constructive uses such as: pipestems, bows, canoe ribs, snowshoes, whistles, drumsticks, basket rims, looms, sweat lodge frames, dreamcatcher frames, rope twine, fishnets, and curling rods for hair.

Wildlife/Forage Usage

Wildlife: Major source of browse for moose, elk, bighorn sheep and deer. Small mammals, birds and beaver eat the shoots, buds, and catkins. Some birds (black-capped chickadees) excavate cavities for nesting. Sapsuckers use the sap extensively (Rawson 1974). Provides cover and protection for many birds and mammals (Tesky 1992).

Livestock: Because these shrubs grow widely scattered, livestock can easily access them. Forage production is moderate to high. Highly palatable for livestock and big game (Tesky 1992). High browsing tolerance (Hardy BBT 1989).

Reclamation Potential

S. bebbiana can be important for revegetation of disturbed sites because of its easy vegetative reproduction and vigorous sprouting under natural conditions. It is adapted to a broad range of soil surface temperature conditions (Zasada and Viereck 1975) and soil textures (Tesky 1992). It is a relatively good soil stabilizer (Tesky 1992).

Commercial Resources

Availability: Seeds not commercially available
Uses: Herbal market, wickerwork, and decorative bark with diamond-shaped patterns (canes, lamp posts, furniture, and candle holders). Willow charcoal used in artist's charcoal pencils (Marles *et al.* 2000).

Notes

S. bebbiana has an optimum seed-bearing age of 10 to 30 years (Hardy BBT 1989).

Scientific Name: **Family:** *Salicaceae*
Salix exigua Nutt.
Common Names: sand bar willow, coyote willow, narrow leaf willow, desert willow.

Plant Description

Perennial, erect, colonial shrubs or small trees, 0.5-4 m high, spreads by extensive creeping rhizomes that form thickets (Uchytil 1989a); branches grayish; leaves parallel-sided linear narrow, 5-13 cm long (5-20 times as long as wide); apex sharply acute, base tapering, shallowly denticulate margins; linear stipules 7 mm long; catkins 1-7 cm long borne on leafy branchlets.

Fruit: Glabrous capsules, 4-7 mm long, narrowly ovoid

Seed: Non–dormant seeds, 1-2 mm long and 4 mm wide attached to the hairs at the radicle end, no endosperm (Zasada *et al.* 2003).

Habitat and Distribution

Commonly found in riparian communities (Uchytil 1989a). Pioneer on slough margins and sandy or gravely floodplains, in wet to moist places along streams, rivers, ditches and roadsides. Intolerant of shade, high tolerance to flooding.

Soil: Tolerant to a wide range of soil textures and soil types. Bare gravel or sand substrate with adequate moisture (Uchytil 1989a).

Distribution: Across North America. Alas to NB, s to S.C., Calif, Tex and NJ.

Phenology

Flowers May to July, fruit ripens June to July.

Pollination

Insects, commonly bees (Uchytil 1989a). *Salix* species are also pollinated by wind (Macdonald 1986).

Genetics

2n=38

***Salix exigua* growing on a reclaimed site in Alberta.**

Seed Processing

Collection: Because *Salix* seeds are quickly dispersed by wind, branches may be cut just before seed dispersal and placed in water for easier seed collection. Seeds are then easily stripped from branches (Macdonald 1986).

Seed weight: 0.0454g/1000seeds (Young and Young 1992).

Seed/fruit: 25 (15–36) seeds/capsule (Zasada *et al.* 2003).

Harvest Dates: When catkins change from green to yellow-brown (June-July). For most efficient seed extraction, wait until the capsules begin to open (Zasada *et al.* 2003).

Cleaning: Dried seeds separate from the cotton if tumbled or shaken (Zasada *et al.* 2003).
Storage: Seed, dried to approximately 6-10% of dry weight, can be stored in sealed containers under constant humidity (Zasada *et al.* 2003).
Longevity: Stored at 1-5°C, dried seeds can remain viable for up to 6 months; if stored at subfreezing temperatures (–10 or –20°C) can last up to 36–44 months (Zasada *et al.* 2003).

Propagation
Natural regeneration: Regenerates by suckering from root system (Zasada *et al.* 2003) and by seed (Gerling *et al.* 1996).
Germination: Seeds require light for germination (Uchytil 1989a). Fresh seeds will germinate within 12 to 24 hours if kept constantly moist (USDA 2002).
Pre–treatments: none required.
Direct Seeding: Direct seeding of fruit was not successful in a trial in northeast Alberta.
Vegetative propagation: Root and twig cuttings (Tannas 1997). If planted in early spring, hardwood cuttings can root rapidly (USDA 2002). Hardwood cutting (7 to 10 inches long and half to 1 inch thick) should be collected and prepared for insertion from November to March. No rooting hormones are required. The rooting percentage of willows is 90-100% (Dirr and Heuser 1987). Cuttings (particularly hardwood) were a successful propagation method on wetland sites in the oil sands reclamation area in Fort McMurray.

Aboriginal/Food Uses
Medicinal: Salicin is a chemical derived from the plant and, chemically, it is related to acetylsalicylic acid (the active ingredient in Aspirin). These chemicals were used by the Native North Americans in preparations to treat toothache, stomach ache, diarrhea, dysentery and dandruff (Uchytil 1989a).
Other: The bark was used by the Woods Cree to make fishing nets, as an aid in canoe-making, and as all-purpose cord. Stems were used to make rims for baskets, bows and arrows, bead weaving looms, and fish-roasting sticks. Flexible branches were also used in the construction of backrests and sweat lodges (Tannas 1997).

***Salix exigua* spreading in lines from a parent plant (off to the right) on a revegetated site.**

Wildlife/Forage Uses
Wildlife: Excellent forage value (Gerling *et al.* 1996). Important food source for beaver, moose and elk. Good to fair browsing for mule deer. Dense stands provide cover for wildlife such as waterfowl, small non–game birds, small mammals, white-tailed deer and mule deer (Uchytil 1989a).
Livestock: One of the less palatable willows (Tannas 1997). High browsing tolerance because of its ability to spread rapidly and form extensive colonies (Tannas 1997). Fair browse for sheep, fair to poor browse for cattle (Uchytil 1989a).

Commercial Resources
Availability: This species is prolific and cuttings can often be harvested from natural sites without harm to the parent site. Numerous nurseries and companies in Alberta and Saskatchewan will contract harvest and production of coyote willow.
Cultivars: Greenbank (Northern Great Plains cultivar)(Stevens *et al.* 2003). Not suitable for reclamation purposes in northeastern Alberta.
Uses: Stabilization of stream bank and lakeshore; development and restoration of riparian habitat and erosion control (Stevens *et al.* 2003).

Reclamation Role

Coyote willow is easily propagated (USDA, 2002). Once planted, sandbar willow requires little care (Stevens *et al.* 2003). Often found as a natural pioneer on disturbed sites along waterways. Because of its rapid rhizome spreading and dense colony formation (thickets may be several meters in diameter), it can be used as an increaser, declining once trees and shrubs become established (Tannas 1997). Used to stabilize sand and gravel deposits thus allowing other species to grow (Uchytil 1989a). In riparian habitats, the dense root system of sandbar willow can serve as an effective shallow groundwater filter and can form overhanging banks which provide habitat for fish and other aquatic living organisms (Stevens *et al.* 2003). Resilient to natural disturbances (sediment deposition, flooding, high winds, heavy precipitations, and wildlife browsing) (USDA 2002).

Notes

Well-adapted to fires, will sprout from roots and its numerous wind-dispersed seeds play an important part in the revegetation of burned areas. Because of its typical streamside habitat, which has higher soil moisture content, sandbar willow communities may act as natural fire breaks (Uchytil 1989a).

Photo credits

Photos: Wild Rose Consulting, Inc.

Scientific Name: **Family:** *Salicaceae*

Salix lucida Muhl.

Common Names: greenleaf willow, shining willow.

Plant Description

Deciduous, perennial, erect, tall shrub or tree 2-9 m high; branches light brown; glossy branchlets; leaves acute to long-acuminate, glandular-serrulate margins, glossy upper surface, and white-bloomed on lower surface; pubescent petioles with 2 glands near leaf-base; catkins borne on long leafy branchlets, staminate and pistillate catkins occur on separate plants.

Fruit: Glabrous capsules, 5-7 mm long, yellowish

Seed: 12-20 minute seeds per capsule, 1-2 mm long and less than 1 mm wide; attached to the hairs at the radicle end; no endosperm (Zasada *et al.* 2003).

Habitat and Distribution

Lake and slough margins, riparian communities, riverbanks, floodplains, wet meadows, sand-dune slacks, and silt bars. Low shade tolerance.

Soil: Wet to mesic soil moisture (Tannas 1997). Adapted to most soils but prefers damp heavy soils (Moore 2003). Pacific willow is an early seral species commonly found on fresh alluvium (Uchytil 1989b).

Distribution: Widespread across North America, and throughout Alberta. Sask to interior Alas, s to s Calif, scattered e to NM and n to Wyo and Ida.

Phenology

Flowers from April to May, and fruit ripen in June.

Pollination

Salix species are pollinated by insects and by wind (Macdonald 1986).

Genetics

2n=76

Male catkins of *Salix lucida*.

Seed Processing

Collection: Because *Salix* seeds are quickly dispersed by wind, branches may be cut just before seed dispersal and placed in water and kept in shed for easier seed collection. The seeds are then easily stripped from branches (Macdonald 1986).

Seed Weight: 0.0395 g/1000seeds (Young and Young 1992).

Harvest Dates: Harvest as soon as fruits ripen, that is, when catkins change from green to yellow-brown.

Cleaning: For most successful seed extraction, wait until the capsules begin to open (Zasada *et al.* 2003).

Storage: Once pre-dried to approximately 6-10% of dry weight, can be stored in sealed containers in such a way that constant humidity can be maintained (Zasada *et al.* 2003).

Longevity: Seeds can remain viable for up to 6 months or more if stored at subfreezing temperatures (1-5°C) (Zasada *et al.* 1983).

Propagation

Natural Regeneration: By tillers and seeds (Gerling *et al.* 1996).

Germination: Fresh seeds germinate within 12-24 hours if kept constantly moist (Moore 2003). The presence of light increases the rate of germination. Significant amounts of chlorophyll are found in the seeds allowing photosynthesis to occur immediately after the seeds are moistened (Uchytil 1989b).

Pre–treatments: None, seeds are not dormant. Seeds are sown immediately after collection on moist ground (Dirr and Heuser 1987).

Direct Seeding: Seeding the fruit was not successful in northeastern Alberta

Vegetative propagation: Zasada *et al.* (2003) recommend stem cuttings. Take hardwood cuttings from mid-fall to early spring, from 1 to 4 year old wood, 7-10 inches long and half to 1 inch thick. Plant cuttings with 25-40% of the cutting left above ground (Moore 2003, Rose *et al.* 1998). Cuttings were a successful propagation method on wetland sites in the oil sands land reclamation area in Fort McMurray: 13% survival of soft tip cutting the 1st year and 15% survival the 2nd year; 36% survival of pole cutting the 1st year and 35% survival the 2nd year.

Aboriginal/Food Uses

Food: Once dried, the inner bark was ground into a powder and then added to flour to make bread.

Medicinal: Salicin is a chemical derived from the plant and it is related to acetylsalicylic acid (the active ingredient in Aspirin). These chemicals are used to treat rheumatism, arthritis, aches and pains, and fever.

Other: Stems and bark used for basket weaving. Native Americans used the bark for making fabric and tea and the stems for making bows.

Wildlife/Forage Usage

Wildlife: Excellent forage value (Gerling *et al.* 1996). Roots create overhanging banks that provide habitat for fish and other aquatic organisms. Beaver browse on willow branches. Willow buds and young twigs are eaten by various species of birds (Stevens *et al.* 2003). Provides food and cover for many species. Deer, elk and moose browse on willow twigs, foliage and bark (Moore 2003).

Livestock: Nutritious plants but low palatability. (Tannas 1997).

Grazing Response: Tolerant to heavy browsing (Tannas 1997).

Reclamation Potential

Easily propagated from vegetative cuttings (Stevens et al 2003). Recommended for reclamation and stabilization of moist, disturbed soils (Tannas 1997). Regenerates quickly following natural and human-related disturbances (flooding, mine tailings, thermally polluted lands, and construction sites) (Zasada *et al.* 2003).

Commercial Resources

Availability: Commercially available in Alberta.

Cultivars: Roland was released by the Alaska Plant Materials Center for revegetation and landscape projects (Uchytil 1989b).

Uses: Landscape, used in tree strips for windbreaks (Moore 2003).

Notes

Following a fire, willows will resprout from the root crown or stem base. Because Pacific willow usually occurs along stream banks, it acts as a natural firebreak. Also, it is a prolific seeder thus making off-site plants important seed source for the revegetation of burned areas (Uchytil 1989a).

Photo Credit

William & Wilma Follette. 1992
Source:
http://commons.wikimedia.org/wiki/Image:
Salix_lucida_lasiandra(02).jpg

Scientific Name: **Family:** *Caprifoliaceae*

Symphoricarpos albus (L.) Blake

Common Names: snowberry, common snowberry, white coralberry

Plant Description

Deciduous, perennial, erect, slender shrub, up to 1 m high, rhizomatous; leaves opposite oval to ovate thin wavy leaves 2-4cm long; clusters of bell-shaped flowers at branch tips, pink and white, hairy within, 4-7 mm long.

Fruit: Dry, waxy berry, white, spherical, 6-12 mm, not edible, two seeds per berry.

Seed: Ivory seeds, 2-3 mm x 3-4 mm flat on one side/round on other, rough.

Habitat and Distribution

Common in bushy areas, open woodland and valley slopes.

Soil: Found on rocky and coarse textured soils. Tolerance to mildly acidic-moderately alkaline soils (Hardy BBT 1989). Adapted to wet and dry soil conditions (Tannas 1997).

Distribution: Widespread across Alberta: parkland, prairie, foothills and across southern boreal forest. s NWT, se Alas and n USA.

Phenology

Flowers June to September. Fruits ripen late June through September.

Pollination

Pollinated by insects and possibly hummingbirds.

Genetics

2n=36, 54, 72

Symbiosis

Is associated with vesicular–arbuscular mychorrizae in British Columbia (Berch et al. 1988).

***Symphoricarpos albus* in flower.**

Seed Processing

Collection: Berries are often found singly or in pairs and are sparse on shrubs making collection more difficult. Handpick or hand-strip fruits directly into picking bags or groundsheets (Banerjee *et al.* 2001).

Seed Weight: 4.81-5.71 g/1000 seeds (5.26 avg)

Fruit/Seed Volume: 3020-3460 fruit/L (3220 avg), 6400 seeds/L fruit

Fruit/Seed Weight: 9000-11 200 fruit/kg (10 000 avg), 20 000 seeds/kg fruit

Average Seeds/fruit: 2 seeds/fruit

Harvest Dates: Ripe fruits are waxy white in colour (Banerjee *et al.* 2001). Collect in late August.

Cleaning: Mash fruit in a sieve (1.40 mm works well). A blender with taped blades may also be used to macerate the fruit. Suspend residue in water allowing seeds to settle. Decant water and chaff. Repeat suspension and decanting until only seeds remain. Alternatively, a tomato de-seeder may be used. Allow seeds to dry at room temperature over a moving air stream.

Storage: Store dry in sealed containers at low temperatures (Young and Young 1998).

Longevity: If kept in sealed containers at low temperature (5°C), dried seeds can be stored for at least 2 years (Young and Young 1992 and Rose *et al.* 1998). McWilliams (2000) had success storing seeds up to 7-10 years.

Propagation

Natural regeneration: By seeds and from suckers (Hardy BBT 1989).

Germination: Field emergence is more successful than *in vitro* germination. There is an increased growth of seedlings in sunlight (Piper 1986). Seeds are dormant and require a double cold period to initiate germination (Smreciu and Barron 1997).

Pre–treatments: Young and Young (1992) recommend 3 months warm stratification followed by 4 months cold stratification.

Direct Seeding: 4% by year 4 on oil sands reclamation sites in northeastern Alberta. Smreciu and Barron (1997) report an abundance of seedlings emerging after 2 winter seasons.

Fruit Sowing: From 0.41% emergence after 2 years (fall sown) to 8.00% emergence after 4 years (spring sown) by sowing fruits. Spring sown (frozen) fruits tend to emerge better than fall sown ones.

Seeding Rate: 50 seeds/m², 12 fruits/m² to obtain 1–2 plants/m².

Vegetative propagation: From suckers (Hardy BBT 1989) and by layering (Babb 1959). Softwood cuttings have been successful with *S. occidentalis* as well as *S. albus* (Smreciu and Barron 1997). Softwoods and semi-hardwood cuttings produce 90-100% rooting from June-August with IBA-talc or solutions of 1000 to 3000 ppm. Hardwood cuttings root 90-100% in 4 to 6 weeks from December-January with 3000 ppm IBA-talc (Dirr and Heuser 1987). Collect 15-20 cm long hardwood cuttings from June to August and stick in soil in shaded area. Store cuttings over winter in damp sawdust or peat moss. In late February to early March, dip in an IBA talc or solution 1000-3000 ppm and stick in potting soil (Rose *et al.* 1998). Containerized seedlings were successful on amended tailings sand (75-92%) (Fedkenheuer *et al.* 1980).

Aboriginal Uses

Food: Inedible, considered poisonous by many native people.

Medicinal: Fruits can be crushed or boiled to make a wash for sore eyes. Root and stem decoction used to treat children teething pain, the wash can be used to treat skin rashes, or can be mixed with other plants to make a tea for venereal disease. Boiled leaves and branches make a diuretic decoction and can treat kidney problems and can be part of a compound aphrodisiac.

Wildlife/Forage Uses

Wildlife: Valuable source of browse for elk, bighorn sheep, white-tailed deer, moose, grizzly bears. Important cover and food source for birds (sharp-tailed, ruffed and blue grouse, wild turkey, kingbird, western flycatcher and western bluebird), and small mammals (fox squirrels, desert cottontails, and pocket gophers) (McWilliams 2000).

Livestock: Important to domestic sheep and cattle (McWilliams 2000). Re–sprouts after grazing (Hardy BBT 1989).

Commercial Resources

Availability: Seedlings are available from local Alberta nurseries.

Reclamation Role

Tolerant of low nutrient sites (Hardy BBT 1989). Extensively used in rehabilitation of disturbed sites. Very good first year survival (75%) on amended tailings sand in northern Alberta (Hardy BBT 1989). Once established, has a good survival rate. Excellent for bank stabilization and erosion control. Previously used for reclamation of tailings sands (Fedkenheuer *et al.* 1980) and on mining sites with acidic, steep tailings (Voeller et al 1998). High resistance to fire (McWilliams 2000).

Notes

After being fed to cattle and digested, the seeds do not undergo scarification or hastened germination, the seeds remain viable for an extended period of time (Doucette *et al.* 2001).

Photo Credit

Source:
http://commons.wikimedia.org/wiki/Image:Symphoricarpos_albus.jpg

Scientific Name: **Family:** *Ericaceae*

Vaccinium myrtilloides Michx.

Common Names: blueberry, velvet-leaf blueberry, Canada blueberry, velvet-leaf huckleberry.

Plant Description

Low evergreen shrub, perennial, 10-50 cm high; pubescent twigs; leaves entire alternate thin velvet elliptic, 1-4 cm long; small and short clusters at branch tips of greenish white to pink flowers, cylindrical bells 3-5 mm long. Radicle develops into taproot finely divided at extremities devoid of root hairs (Vander Kloet et al 1981), long tapering structure typical of a root (as deep as 1 m) and rhizomes have a stem-like structure (Hall 1957). Rhizomes 3-11 cm deep (Smith 1962, Flinn and Wein 1977). Branching, deeper roots were found by Smith (1962) but no taproots.

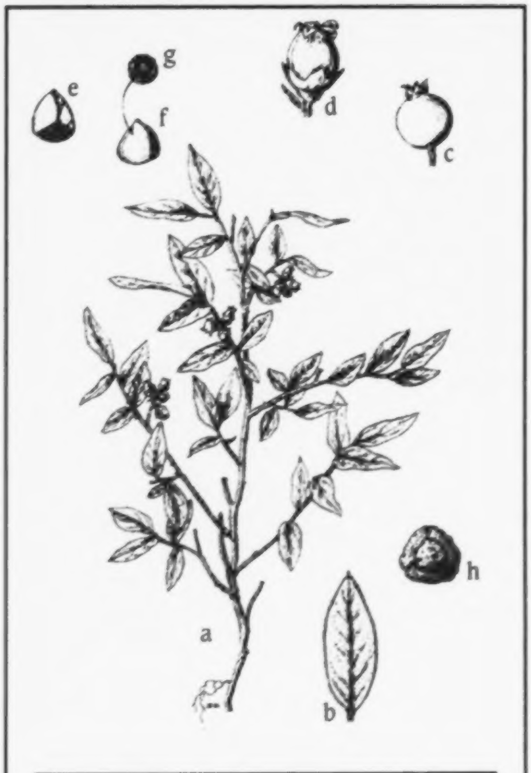
Fruit: Blue with whitish bloom, 4-8 mm wide, spherical, edible berry, average of 37 seeds per berry.

Seed: 1 mm ovoid to obconical, umber brown, rugose seeds.

Vaccinium myrtilloides **in flower.**

Habitat and Distribution

Lowbush blueberry is common on acidic soil (pH from 3.0-5.9) in peat bogs, muskegs, peatlands, alpine and mountain meadows, sandy soils in open forests and clearings. Relatively intolerant to shade (Rogers 1974).



***Vaccinium myrtilloides*. a. branch with inflorescence and leaves, b. leaf, c. fruit, d. flower, e-f. seed, g. seed surface, h. pollen.**

Soil: Optimum pH range of 4.0-5.5. Requires acidic soils, grows well on sandy loam soils (Carter 1996). Most productive in light, well-drained acidic soils high in organic matter. Common on stony, silt, and clay loam soils (Rogers 1974).

Distribution: Common in the boreal forest. In North America, s Mack to s Hds Bay, Nfld, s to Mont, s Sask, s Man, Ida, Great Lakes and Va. Widespread and circumboreal.

Phenology
Flowers in April through July (Banerjee *et al.* 2001). Fruit ripens in July through August (Dirr and Hauser 1987).

Pollination
Andrenids, some *Bombus* spp. (Vander Kloet et al 1981, Reader 1977), and *Apis mellifera* L. (Whidden 1996). *Andrenids* and *Apis* are the most common, however *Bombus* are the most effective (Whidden 1996).

Genetics
2n=24

Symbiosis
Blueberry associates with the ericoid mycorrhiza fungi with a diverse assemblage of fungal endophytes (e.g. Hymenoscyphus ericae) (Hambleton et al. 1999, Massicotte et al. 2005) that increase effectiveness of nitrogen uptake in high acidic soils (Jans and Vostka 2000).

Seed Processing
Harvest Dates: Late July, when the fruit is bluish black and bloomy.
Collection: Although time consuming, berries borne in clumps on these low shrubs are not difficult to collect. Handpick or hand-strip directly into picking bags or onto ground sheets.
Seed Weight: 0.060-0.214 g/1000 seeds (0.147 avg).
Fruit Volume: 1870-3380 fruit/L (2540 avg), 93 800 seeds/L fruit
Fruit Weight: 3740-7070fruit/kg (5240 avg), 194 000 seeds/kg fruit
Average Seeds/fruit: 37 seeds/fruit
Cleaning: Macerate in blender for 20-30 sec on stir with equal amount of water, decant water and chaff. Repeat suspension and decanting until only seeds remain. Allow seeds to dry at room temperature over a moving air stream.
Storage: Store at cool temperatures (Young and Young 1992).

Vaccinium myrtilloides **plant in fruit.**

Longevity: 5 year old seeds can still be viable (Granström 1987).

Propagation
Natural Regeneration: Both by seed and vegetatively (Tirmenstein 1990). Vegetative spread is mainly via laterally branched woody rhizomes that can establish dense mats (Carter 1996). Reproduces from sprouts and suckers (Rogers 1974).
Germination: Most successful in 1:1 sand-peat mixtures at a pH of 4.5 (Tirmenstein 1990). Bimodal germination at 18 and ~80 days up to 30% (Vander Kloet 1994). Smreciu *et al.* (2006) obtained 10 % germination in 90 days with fresh, 1 or 2 year old seeds. Young and Young (1992) report that light can increase the success of seed germination.
Pre–treatments: Often not required as many seeds are mostly non-dormant however 1 or 2

months of stratification is used by Smoky Lake Forest Nursery (Hennie Darago, pers. comm).

Direct Seeding: No significant emergence observed by sowing seeds, only small seedlings were observed in latter years on oil sands reclamation sites in northeasetrn Alberta. Emerged from fruit; fall sowing did slightly better than spring sowing when frozen seeds were used. Direct fruit sowing produced slightly greater emergence than direct seed sowing.

Seedling Development: Radicles 20 days after seeding, cotyledons 31 days, first true leaves 48 days (Vander Kloet et al 1981) and can be transplanted 6-7 weeks after emergence (Rook 1998).

Vegetative Propagation: Can be propagated from 10-13 cm long hardwood cuttings but difficult to root (Rook 1998). Harvest rhizome cuttings in early spring or late summer and autumn (Dirr and Hause 1987). Generally propagated from softwood cuttings 7-8 cm in length however, micro propagation (tissue culture) is more successful (Carter and St–Pierre 1996). Babb (1959) suggests using division.

Micropropagation: Nickerson (1978) reports successful propagation through cultured seedling explants (excision and culture of cotyledons and hypocotyls).

Aboriginal/Food Uses

Food: *V. myrtilloides* is one of the most important fruits for local native people. Eaten fresh, cooked with sugar or lard, canned, or sun dried. Dried fruit can be mixed to pemmican. Beverages can be made by boiling the dried leaves.

Medicinal: Eating the fruits relieves acne; blueberry syrup can treat vomiting and stems can be boiled to make a tea to prevent pregnancy. When combined with other plants, can prevent miscarriage, increase bleeding after childbirth, regulate menstruation, and stimulate sweating. The whole plant can be used as medicine to treat cancer. A decoction made from boiling the roots can be taken to relieve headaches.

Wildlife/Forage Uses

Wildlife: Berries are an extremely important food source for black bear and grizzly bear. White-tailed deer and eastern cottontail browse the leaves and twigs. Many mammals feed on the berries (white-tailed deer, red fox, porcupine, raccoon, mice, chipmunks, pika, white-footed mouse, grey fox, ground squirrel, deer mice, and skunks). Many birds also feed on the fruit (wild turkey, grey catbird, band-tailed pigeon, ring-necked pheasant, and quails, ptarmigans, towhees, spruce, ruffed, blue, and sharp-tailed grouse, American robin, American crow, bluebirds, and various other small birds) (Tirmenstein 1990).

Livestock: Browse is of relatively low palatability to most domestic livestock (Tannas 1997).

Commercial Resources

Harvest Methods: By handpicking, with hand rakes and mechanical harvesters. Mechanical harvesters range from over-the-row to hand-held vibrators with catch frames. Some berry loss is inevitable with this method.

Availability: Although commercially available, local stock may be difficult to purchase.

Cultivars: Many different clones (over 1000) are available from Nova Scotia (Carter 1996) but are not suitable for reclamation purposes.

Uses: Fresh fruit, jams, syrups. Potential for value-added food and beverage products (Marles *et al.* 2000).

Reclamation Role

Valuable ground cover species in areas of low vegetation cover (Tannas 1997). Requires minimum site preparation. Popular edible berry for both humans and animals. Because of its vegetative system, *V. myrtilloides* can withstand moderate disturbances. Carter (1996) reports that blueberries are excellent colonizers of disturbed areas. Haeussler *et al.* (1999) found that they are sensitive to high severity disturbances (natural and mechanical) and exhibit a slow recovery. However, moderate disturbances such as partial cutting can significantly improve berry production. This is possibly due to increased light availability. In order for the *V. myrtilloides* to expand and dominate an understory area, the faster growing hardwood species, which are aggressive competitors and invaders, must be suppressed and controlled (Moola and Mallik 1998). Moderate shade however is necessary because it aids in moisture conservation and foliage sunburn prevention (Smith 1962).

Notes

Compared to other fruit crop species, *V. myrtilloides* has low nutrient requirements (Carter 1996). Because of their deep subterranean reproductive plant parts (4 cm below the mineral soil), blueberries have a high survival rate during fire (Flynn and Wein 1977). Studies have shown that to maximize yield, significant stands of *V. myrtilloides* should be burnt every third year (Vander Kloet 1994).

Photo Credits

Photo 1 – Flowering plant: Glen Lee, Regina, SK
Photo 2 – Plant in fruit: Wild Rose Consulting, Inc.
Line Diagram: John Maywood, used with permission of Bruce Peel Special Collections, University of

Scientific Name: **Family:** *Ericaceae*

Vaccinium vitis-idaea L.

Common Names: bog cranberry, cowberry, lingonberry, lowbush cranberry, mountain cranberry, partridgeberry, northern mountain cranberry.

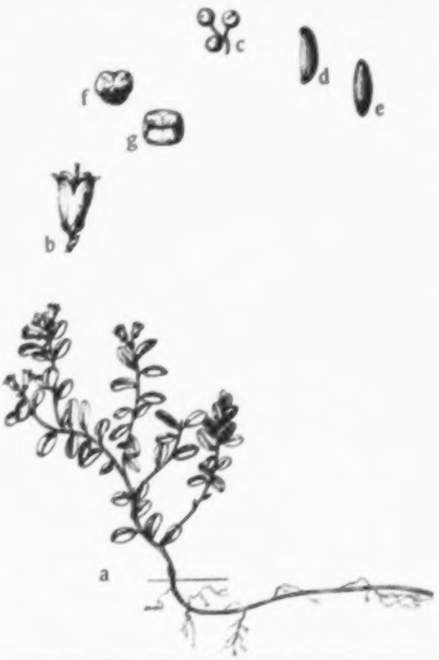
Plant Description

Perennial, semi-erect or creeping dwarf shrub, 5-20 cm high; forms large clones; fine hair-like roots from rhizomes with maximum rooting depths of 5-28 cm (Tirmenstein 1991), occasionally a taproot; stem creeping or trailing; leaves evergreen, alternate, entire (not toothed), shiny above, pale with black glandular dots beneath, thick, rolled edges (under), 6-15 mm long, leaves turn purple to red in the fall; inflorescence a short terminal cluster of 5-15 flowers; flower rose to white, cup shaped, 5 mm diameter.

Vaccinium vitis-idaea **plant growing in moss.**

Fruit: Carmine, spherical berry, 5-10 mm diameter; edible, acidic; 3-15 seeds/berry – average of 12 seeds per fruit.

Seed: 1 mm long, egg-shaped, brown to yellow, smooth to rough texture with a short beak.



Vaccinium vitis-idaea **a. plant with flowers, leaves and underground rhizome and roots, b. flower, c. fruit, d-e. seeds, f–g. pollen.**

Habitat and Distribution

Habitat: Northern temperate forests; dry, open woods particularly as a subdominant under *Pinus* spp. and *Betula papyrifera*, open spruce (*Picea* spp.) and aspen (*Populus tremuloides*) woods; dry bogs with *Sphagnum* moss and *Picea mariana* and *Larix laricina* and alpine slopes. Can tolerate shade but blooms more abundantly in more open areas. Drought-resistant.

Seral Stage: Not generally a pioneer species but can be an early invader in some communities.

Soils: Dry, poorly developed, mineral soils or well-drained peat bogs; best on pH 4.0-4.9.

Distribution: Very common and widespread across boreal forest, aspen parkland, and montane regions of Alberta; Alas, Yuk, sBaffin, Nfld, s to BC, Alta, cSask, sMan, sJames Bay, sQue, s to N. Eng. and Gr Lk States. Circumpolar and circumboreal.

Phenology

Vegetative growth resumes in late May to early June; flowers in late June and July (early August), fruit ripens in late August and September; leaves often turn reddish-purple in fall as dormancy commences; rhizomes grow actively in spring and fall.

Pollination

Pollinated by bumblebees or syrphid flies, and butterflies (Rook 1998). Self- or cross-pollinated but more fruit is produced if cross-pollinated (Hall and Beil 1970).

Genetics

2n = 24

Symbiosis

Forms ericoid mycorrhizas with a diverse assemblage of fungal endophytes (*e.g. Hymenoscyphus ericae*) (Hambleton *et al.* 1999, Massicotte *et al.* 2005). *V. vitis-idaea* is host of the root endophytic fungus *Phialocephala fortinii* (Addy *et al.* 2000).

Seed Processing

Harvest Dates: Late August early September.
Collection: Low growing plants make collection difficult; hand collection is time consuming.
Seed Weight: 0.14-0.323 g/1000 seeds (0.205 avg)
Fruit/Seed Volume: 1850-4780 fruit/L (3190 avg), 38 200 seeds/L fruit
Fruit/Seed Weight: 380-10 200 fruit/kg (7050 avg), 84 600 seeds/kg fruit
Average Seeds/fruit: 12 seeds/fruit
Cleaning: Place pulpy fruits in a blender (use about 3:1 water with fruit) on low speed until fruits are fully macerated (20-30 seconds). Pour through sieve(s) to remove chaff smaller than seeds. Re-suspend residue in water and mix; allow seeds to settle and decant water with floating and suspended larger chaff. Repeat re-suspension step until seeds are clean; sieve if necessary and place seeds on paper toweling or cloths to dry. Dry at room temperature or up to 25°C over a moving air stream.
Storage: store dry at ambient room temperatures; fruit can be frozen soon after collection and seeds removed up to several years later.
Longevity: 5 year old seeds can remain viable (Granström 1987).

Vaccinium vitis-idaea **flowers.**

Propagation

Natural Regeneration: Spreads by rhizomes and can form dense patches (St-Pierre 1996).
Germination: >85% germination after 60-90 days stratification with fresh or one year old seeds. Baskin *et al.* (2000) found that germination increased significantly in the presence of light after 12-20 weeks of stratification. The best

substrate for seed germination noted by Holloway (1981) is milled peat or an equal mixture of peat and sand.

Pre–treatments: Stratification of 60-90 days for fresh or older seeds; seed lots extracted from fruit frozen for several years germinated reasonably well after a 28 day stratification.

Direct Seeding: No significant emergence observed, only small seedlings observed in latter years.

Fruit Sowing: Produced small seedlings (0.58% after 4 years in the fall trial). Direct fruit sowing produced slightly greater emergence than direct seed sowing.

Vegetative Propagation: Plants enlarge by means of horizontal rhizomes and by nodal rooting of above-ground branches; daughter plants can be separated from parent plants. Semi-hardwood cuttings collected in early May root well when treated with Stim-root #3 (Smreciu and Gould 2003; Dirr and Heuser 1987). Babb (1959) suggests by division. Stem cuttings propagated in the spring have been successful. The best rooting media is milled peat (Holloway 1981).

Micro–propagation: Leaf explants placed with the adaxial side in contact with zeatin (a medium with 5-30 μM ZN) with a seven day dark treatment were the best conditions for organogenesis (Debnath and McRae 2002).

Aboriginal/Food Uses

Food: Primarily berries are used for food; berries eaten fresh: made into sauce and jelly and used in pemmican. Rich in vitamin C.

Medicinal: Ho *et al.* (2001) isolated the active components of *Vaccinium vitis-idaea* and found that it may be used as an alternative treatment of periodontal disease. The active ingredients were identified as: arbutin, hyperin, hydroquinone, isoquarcetin and tannins. Used raw to relieve fevers, sore throats and upset stomachs. Berries were used in hot packs to treat swellings, aches, pains, and headaches.

Wildlife/Forage Usage

Wildlife: Browsed by black bear, moose, caribou and snowshoe hare; berries are an important source of food for black bears in fall and spring, for grouse and for migrating birds in spring and for numerous other birds; berries also eaten by red-backed voles and red fox in fall; numerous small mammals burrow under snow to obtain fruits that persist on plant.

Livestock: Plants are of little value to livestock; eaten by domestic sheep if more preferable species are unavailable.

Reclamation Potential

Proven survival on extremely harsh sites. Well-adapted to fire. Its vigour and cover increases following a light fire (St-Pierre 1996).

Commercial Resources

Harvest Methods: Hand harvested, can also use small hand rake

Availability: Commercially produced in Europe, Newfoundland, and Labrador. Harvested from wild in Nova-Scotia and in LaRonge, Sk. Very small market in USA, largest crop being from Oregon (Small *et al.* 2003).

Cultivars: Eurasian cultivars are available for fruit production (St-Pierre 1996) but these are not suitable for reclamation purposes.

Uses: Bog cranberry is an important berry crop in many parts of northern Europe and to a lesser extent in North America. It is primarily wild harvested. Products from the berries include jams, jellies, syrups, juices, sauces candies, wines and liqueurs. Also used as ornamental landscape plants, good for ground covers and edging plants. Arbutin is extracted from the leaves of this plant and used by the pharmaceutical industry to produce preparations to treat intestinal disorders (Marles *et al.* 2000).

Photo credits

Photos: Glen Lee, Regina, SK.
Line Diagram: John Maywood, used by permission of Bruce Peel Special Collections, University of Alberta.

Scientific Name: **Family:** *Araceae*

Acorus americanus (Raf.) Raf.

Common Names: rat root, sweet flag, calamus

Plant Description

Herbaceous perennial from thick rootstocks; Aquatic erect perennial herb, 40-80 cm growing from an aromatic thick, creeping rhizome often forming mats; leaf-like erect stem bears a lateral spadix 3-8cm long; leaves basal, alternate, 40-80 cm long and 8-20 mm broad, linear, flat; stem/scape resembles leaves; spadix borne laterally partway up the flat stem, 3-8 cm long, covered with yellow-brown flowers; flowers perfect, 6 scale-like sepals, ovary 2-3 loculed, thick creeping rootstock.

Fruit: Hard dry fruit, gelatinous inside, bearing a single achene (Johnson *et al.* 1995)

Seed: 3 mm, lentiform seeds, cream coloured.

Habitat and Distribution

Marshes, shallow water and stream edges, ephemeral streams, and swamps.

Soils: Organic, poorly drained soils. Moist soils found in riparian areas. Sweet flag is intolerant to droughty soils, but tolerant to seasonal and permanent flooding with 15-50 cm maximum water depths (Cooper *et al.* 2006). The pH range is 5.3-7.2, weakly acid to weakly basic conditions (USDA NRCS 2004).

Distribution: Central and northern Alberta; BC to NS, south to Mont, Tex and Fla. Scattered across southern boreal forest.

Phenology

Flowers May to August. Seeds ripen late summer or early fall (Bush 2002).

Pollination

Based on morphology, Cook (1988) suggests that *Acorus* is insect pollinated.

Genetics

2n=24

Acorus calamus **spadex and spathe (flowering florescence and bract).**

Symbiosis

Plants from Ohio (*A. calamus*) have vesicular–arbuscular mycorrhizal (Bohrer *et al.* 2004).

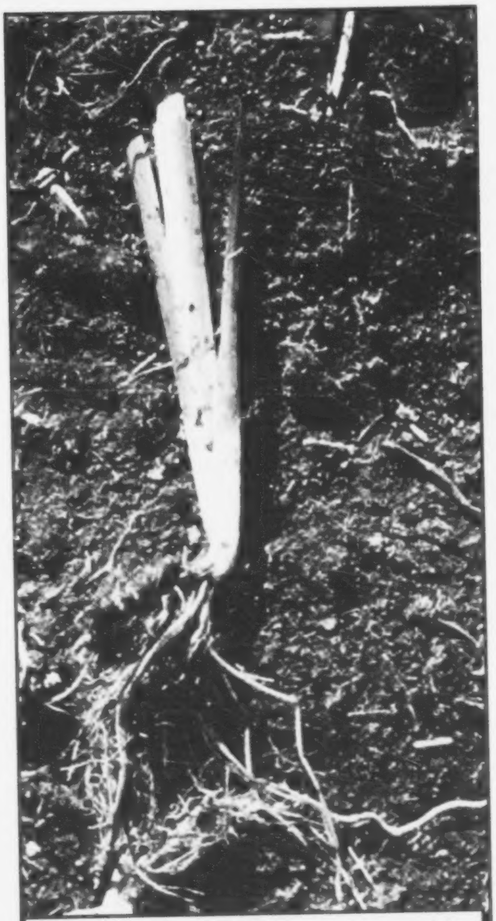
Seed Processing

Harvest Dates: late summer or early fall (Bush 2002).

Collection: Heads can be hand–picked or snipped.

Seed Weight: 0.526 -0.922 g/1000 seeds (0.746 avg).

Cleaning: Air-dry fruit at 15-25°C. Crush material or remove large chaff and crush remaining material. Sieve to remove seeds from chaff



Rhizome cutting of *Acorus calamus* with attached leaves and roots.

using appropriate size screens. Small chaff and dust can be removed by winnowing.

Storage: Store in sealed containers.

Propagation

Natural Regeneration: By seed (Bush 2002) and by rhizome division.

Germination: Very poor (<10%) with seeds harvested in northeastern Alberta. Requires moist to saturated substrate and full sun (Motley 1994). Shipley and Parent (1991) obtain 91% after 30 days using 9 months old seeds from Ontario planted in pots filled with acid-washed sand and remaining 1 cm filled with a commercial potting soil.

Pre–treatments: None required (Bush 2002). Placed in porous nylon bags and buried in wet sand for 9 months of cold stratification (4°C) (Shipley and Parent 1991).

Direct Seeding: Germinates in less than 2 weeks with direct seeding (Bush 2002).

Vegetative propagation: Propagated by plant or rhizome division. There was a 38% survival of non-leafy rhizome cuttings the first year and 23% survival after 3 years; a 71% survival of leafy rhizomes the first year and 37% survival after 3 years in northeastern Alberta Oil Sands tailing pond.

Aboriginal/Food Uses

Medicinal: The bitter and aromatic rhizomes are highly valued as a multiple-usage medicine. Rhizome is chewed to treat colds and coughs, rheumatism, toothaches, headaches, muscle pain, and intestinal worms. Boiled rhizome may be used as an expectorant and to treat tonsillitis, sinus congestion, pneumonia, diabetes, high blood pressure or menstrual cramps. Also used as an antibiotic and insecticide.

Wildlife/Forage Usage

Wildlife: Rhizomes are eaten by muskrats and seeds are eaten by wood ducks. Waterfowl use sweet flag for habitat (Bush 2002).

Livestock: Little or no value for stock.

Commercial Resources

Harvest Methods: None known; but there must be mechanical harvest methods for use in pharmaceutical trade.

Availability: Could be developed as an aqua–cultural product by modifying wild rice production methods (Marles *et al.* 2000).

Cultivars: none known

Uses: essential oil for aromatherapy.

Notes

Chromosome studies have shown that *Acorus calamus* plants are tetraploid and fertile in Asia, triploid and sterile in Europe, and mostly diploid and fertile in North America. Some authors believe that the North American diploids should be recognized as a distinct species, *Acorus americanus* (Rafinesque) Rafinesque. As for the eastern North American triploid populations, they are believed to have been introduced by early European settlers (Packer and Ringius 1984, Motley 1994). It is possible that there was intentional propagation of *Acorus* in some locations by Aboriginal people (Marles *et al.* 2000).

Acorus calamus can survive long periods of anoxia (oxygen deprivation; Joly and Brändle 1995).

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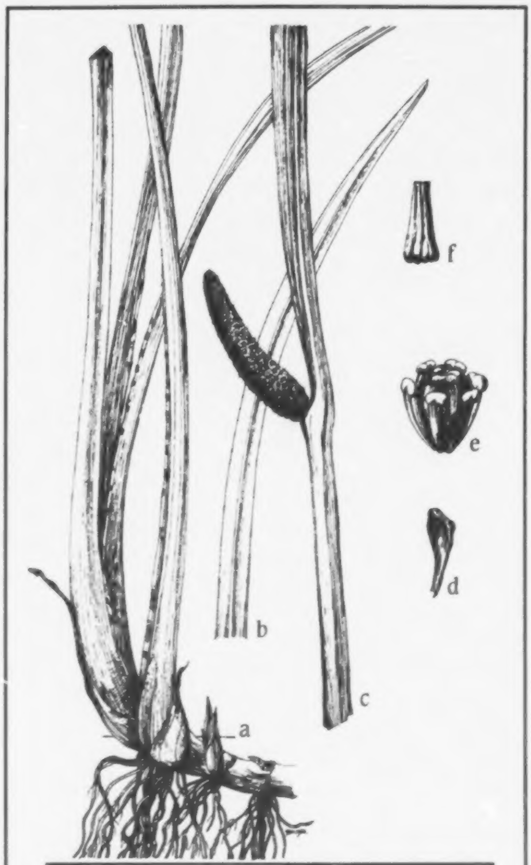
Photos 1 and 2: Wild Rose Consulting, Inc
Line Diagram: John Maywood, with permission from Bruce Peel Special Collection, University of Alberta.



Acorus calamus. **a. leaves, rhizome and roots b. leaf c. flowering stalk d. bract e. stamens and pistil f. seed.**

Scientific Name: **Family:** *Asteraceae*

Aster puniceus L.

Common Names: purple stem aster

Plant Description

Perennial herb growing from thick rhizome, stout stem 0.5-1.5 m high, reddish purple, simple or branching above, with spreading hairs; alternate lanceolate to oblong leaves 6-16 cm long, 1-2 cm wide, sessile, distantly serrate or occasionally entire, hairy beneath and hairy leaf midribs; numerous flower heads in leafy cluster, 30-60 ray flowers blue to purplish 8-16 mm long, disc flowers yellow; slender loose bracts, involucres 6-12 mm high

Fruit/Seed: Hairy achenes with white pappus hairs.

Habitat and Distribution

Fairly common in swamps and marshy ground. Found in wet, grassy roadside ditches. Moderately shade tolerant.

Soil: Requires moist soil and can grow in nutritionally poor, light to heavy textured soils (Fern 1997).

Distribution: Fairly common in boreal forest across prairies; n to Lake Athabasca; Alta to Nfld s to SD, Kans, Ia, Ill, Ala and Ga.

Phenology

Flowers from June to November. Seeds ripen in August through September. Late flowers often fail to produce seeds due to a lack of pollination.

Pollination

Flowers are pollinated by bees, flies, beetles and Lepidoptera (moths and butterflies). Purple stem aster is self-fertile (Fern 1997).

Genetics

2n=16

Seed Processing

Collection: Hand picking; entire stems can be cut and dried to allow additional seed ripening.

Aster puniceus in flower

Seed Weight: 0.14 – 0.23 g/1000seeds (0.19 avg).

Harvest Dates: August in northeastern Alberta.

Cleaning: Pull seeds from seed heads by hand. Rub seeds with pappus between corrugated rubber in a box. Sieve to remove seeds from chaff using appropriate size screens. Small chaff and dust can be removed by winnowing. Alternately, pappus with attached seeds can be placed on a sieve with opening size large enough to let seeds through stacked on a sieve that will catch the seeds. Place a smaller sieve over the top sieve and direct a strong flow of air (such as that produced by a reversed vacuum) through the top sieve. Seeds will be removed from the pappus and lodge in the small mesh sieve.

Storage: store seeds dry.

Longevity: some germination has been recorded in six-year-old seeds stored at room temperatures.

Propagation

Germination: 25% germination in 30 days with fresh, 1 or 2 year old seed from northeastern Alberta.

Pre–treatments: 30 days cold stratification.

Vegetative Propagation: Can be propagated by division in spring or autumn (Fern 1997). Leafy rhizome cuttings survive well when planted on a moist reclaimed site in northeastern Alberta.

Aboriginal/Food Uses

Medicinal: Aboveground parts are dried and boiled to make a decoction to treat kidney problems, chills, and cold sweats when drunk repeatedly. If collected when plants are in flower, the stems, leaves and flowers can be used to treat headaches. Dried roots can be mixed with tobacco or made into a powder and inhaled to treat headaches or chewed and applied to sore teeth. Roots can be used as a heart medicine, a diuretic, emetic tea, medicine for sore kidneys, fever, teething sickness, failure to menstruate, recovery after childbirth and facial paralysis. Purple stem aster has proven anti-inflammatory properties

Commercial Resources

Availability: Occasionally small amounts of seed are offered by nurseries or seed producers in Alberta.

Reclamation Role

Spreads rapidly and forms large colonies in wet meadows and ditches of northeastern North America (Taylor and Hamblin 1976).

Photo Credits

Photo 1: Colby College, www.colby-sawyer.edu/images/

Scientific Name: **Family:** *Scrophulariaceae*

Castilleja raupii Pennell

Common Names: purple paintbrush, Raup's Indian paintbrush

Plant Description

Erect short-lived perennial herb, 30-50 cm high; slender, green or purplish stem, distinctly hairy; leaves alternate, linear, sessile 4-5 cm long; dense terminal spikes; brightly pink to purple bracts are more obvious than petals, oval to lance-shaped, paired, fuzzy; short weak roots, partially parasitic.

Fruit: Oval shaped capsule is more pointed than egg–shaped;

Seed: 1.5-3 mm long, silvery, irregularly shaped seeds, ridged, honey-comb-like surface texture.

Habitat and Distribution

Habitat: Roadsides, open moist forests, forest margins, grassy areas, bogs and shores.

Seral Stage: Early to mid seral species.

Soils: Moist to well drained soils with some organic matter.

Distribution: Boreal forests in Alberta. Man w to Mack delta and s Alas.

Phenology

Bracts gain colour and plant blooms in late June and July. Seeds ripen in late July and August.

Pollination

The *Castilleja* genus is generally pollinated by hummingbirds and/or are self-pollinating.

Genetics

2n=72

Symbiosis

Partially parasitic, *C. raupii* infects roots of a wide range of angiosperm families. This parasitic habit increases its vigour with more branching, greater height and earlier flowering (Heckard 1962).

Castilleja raupii **– a multi–stemmed herbaceous annual or short–lived perennial.**

Seed Processing

Collection: Care should be taken to avoid pulling up plants by the weak roots. The tops can be cut.

Seed Weight: 0.06-0.009 g/1000 seeds (0.07 avg).

Harvest Dates: Late July and late August

Cleaning: Air-dry fruits. Crush material or remove large chaff and crush remaining material. Sieve to remove seeds from chaff using appropriate size screens. Small chaff and dust can be removed by winnowing. If capsules

are intact merely open capsules and empty seeds; sieve or winnow to remove chaff .
Storage: Store dry in sealed containers (due to light weight seeds are easily blown away).
Longevity: Seed viable for at least two years.

Propagation
Natural Regeneration: From seed (Gerling *et al.* 1996).
Germination: More than 80% in 30 days, fresh, 1 or 2 year old seed in northeastern Alberta.
Pre–treatments: Cold stratification of 30 days.
Direct Seeding: 0.43% emergence after the first year and fully established by year four (flowering, producing seeds and spreading) on oil sands reclamation sites in northeastern Alberta
Seeding Rate: 500 seeds/m² to obtain 2 plants/m² – these will spread by seed to produce a much greater density after 3–5 years.

Aboriginal Uses
Connected to love charms and medicines.

Wildlife/Forage Usage
Wildlife: Fair forage value (Gerling *et al.* 1996)
Livestock: Poor forage value (Gerling *et al.* 1996)
Grazing Response: Increases in abundance following grazing (Gerling *et al.* 1996).

Commercial Resources
Availability: Plants are occasionally available from local Alberta nurseries.

Photo Credit
Photos: Wild Rose Consulting, Inc.

Castilleja raupii **seedling growing in a direct–seeded revegetation plot.**

Scientific Name: **Family:** *Cyperaceae*

Eleocharis palustris L.

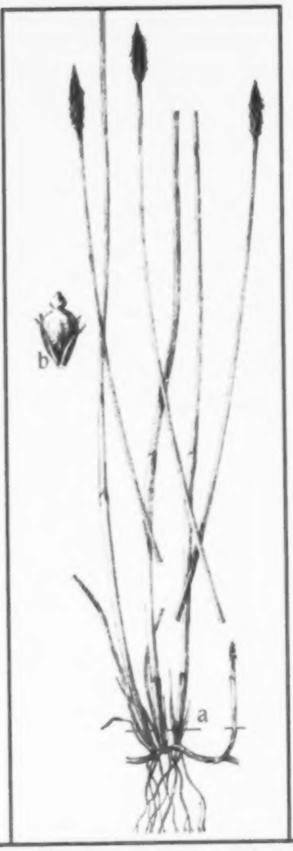
Common Names: creeping spikerush, common spikerush, spike sedge

Plant Description

Perennial, graminoid in growth, with stout creeping rhizomes, forming dense mats (stands can be 30 cm-2 m in diameter; Hauser 2006); tufted culms, somewhat flattened stems 10-100 cm high; leaves are bladeless sheaths at base of stems; single, narrowly ovoid to lanceolate spikelet at stem tip, conical and brown, 0.5-2 cm long; 1-3 sterile scales at base of spikelet, fertile scales are lanceolate and acute and usually have firm mid vein to the apex; 2 stigmas.

Fruit/Seed: Yellow-brown lens-shaped achenes 1-1.5 mm long, conical swelling at tip (half the width of the achene), usually 4 barbed bristles somewhat longer than achene.

Eleocharis palustris **flower head.**



Eleocharis palustris a. **showing roots and rhizomes and flowering stems and leaves, b. achene (seed).**

Habitat and Distribution

Wet places, marshes, wet meadows, ditches, mud flats, along stream banks, lakeshores and flood areas. It is shade tolerant but drought intolerant (Hauser 2006). Adapted to saturated sites or areas of seasonal inundation.

Seral Stage: colonizer on newly developed wetlands; decreases with competition but can be found in all seral stages.

Soil: Grows in a variety of soils: alkaline, sand loams, sedimentary peat, organic loams (Snyder 1992). Adapted to coarse and fine textured soils, it can withstand anaerobic soil conditions and is found on heavy clays (Hauser 2006). Soil pH ranges from 4-8 (Hauser 2006).

Distribution: Common and widespread across Alta and across North America, n to the tree line. Circumpolar: Alas, Yuk to Hudson Bay, n Que and Nfld.

Phenology

Flowers from June to September. Seeds ripen in late August to October (USDA NRCS 2006).

Pollination

Wind-pollinated (Hauser 2006).

Genetics

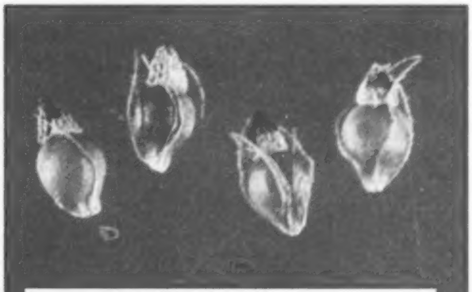
2n=10-96

Symbiosis

Colonized by vesicular-arbuscular mycorrhizal fungi (Bohrer *et al.* 2004). According to Ogle (2005), common spikerush is associated with VA mycorrhiza and has the ability to fix atmospheric nitrogen and makes it available to other plant species in the wetland community.

Seed Processing

Collection: Harvest by hand, stripping or clipping with hand shears (USDA 2006). Power seed harvesters may also be used (Ogle 2005). Handheld seed strippers can be used in dense patches. Can produce prodigious amounts of seed but viability is low (Hauser 2006).
Cleaning: Hammer mill can be used to break up large debris and free seeds (Ogle 2005).



***Eleocharis palustris* seeds.**

Propagation

Natural Regeneration: Spreads rapidly by rhizomes and occasionally by seed (Ogle, 2005).
Germination: Should start germinating after 7-14 days (Ogle 2005). Light, moisture, and heat are required for seed germination (USDA 2006).
Pre–treatments: Light seed scarification followed by 30-45 days cold stratification (2°C) in a mixture of water and sphagnum moss (Ogle 2005); Eight percent germination after 30 days following a 9-month cold stratification at 4°C (Shipley and Parent 1991).
Direct Seeding: 5% germination rate, after 5 years of growth, germinated seeds were firmly established and thriving (Hauser 2006)
Vegetative Propagation: 63% survival of rhizome sprigs (Tannas 1997) the first year and 42% survival by year 2; spreads extensively in wet areas.
Transplant Spacing: 30-45 cm apart.

Wildlife/Forage Uses

Wildlife: Important food source and cover for waterfowl (Snyder 1992). Also provides cover for many small mammals. Seeds, stems and rhizomes are an important food source for a variety of waterfowl, marsh and songbirds. Seeds are eaten by ducks and shoots are grazed by geese (Ogle 2005). *E. palustris* has fair food value for elk and mule deer (Hauser 2006).
Livestock: Tops are heavily grazed by livestock especially after seed set. *E. palustris* may increase in response to grazing (Snyder 1992). Low palatability (Hauser 2006).
Grazing Response: Although Tannas (1997) notes it is fairly resistant to heavy grazing and trampling, Hauser (2006) states it is highly susceptible to trampling in wetland areas.

Commercial Resources

Availability: Not available commercially in Alberta or Saskatchewan (Tannas 1997).
Cultivars: Numerous cultivars are available in the U.S. but these are not suitable for reclamation in Alberta.

Reclamation Role

Common spikerush can be used for wetland restoration and for development and improvement of plant diversity in wetland and riparian habitats (USDA NRCS 2006). Reported to naturally colonize reclaimed wetland sites in the oil sands region of Alberta (Cooper *et al.*

2006). Because of its extensive rhizome formation, it is good for erosion prevention and for soil building (Tannas 1997).

Notes

Because of its sprouting rhizomes, the common spikerush is well adapted to fire. The underground rhizomes usually remain undamaged by fire because the common spikerush grows in saturated or flooded soils (Hauser 2006).

Photo Credits

Photo 1: Eleocharis palustris flowering head
Kristian Peters
Source: Fabelfroh 10:17, 10 May 2007 (UTC)
Photo 2: Eleocharis palustris seeds
Steve Hurst
Source:
http://plants.usda.gov/java/profile?symbol=ELPA3&photoID=elpa3_003_ahp.tif
Line Diagram: John Maywood, used by permission of Bruce Peel Special Collections, University of Alberta

Scientific Name: **Family:** *Liliaceae*

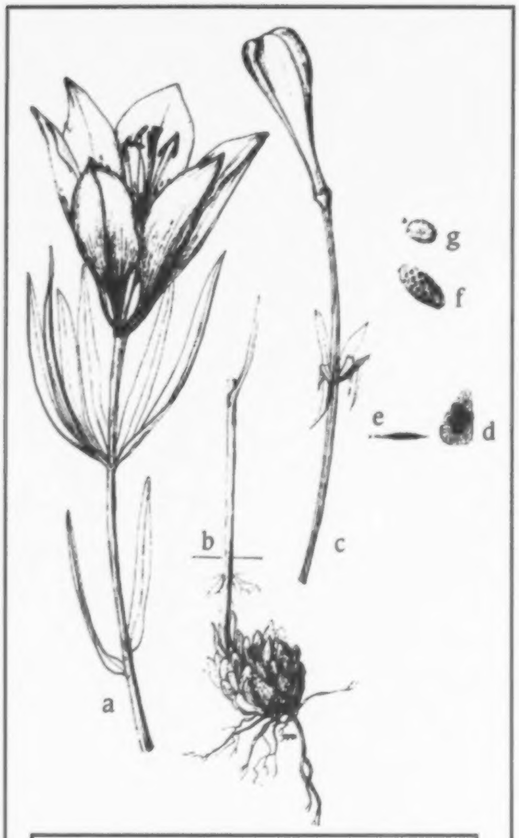
Lilium philadelphicum L.

Common Names: tiger lily, prairie lily, wild lily, red lily, western red lily

Plant Description

Erect, smooth, leafy perennial, 30-60 cm high; leaves 5-10 cm, linear to lance-shaped, alternate, whorled at flower; single or triple bloom per stem; orange to red, dotted black/purple petals and sepals, 5-8 cm long, dark purple anthers; white, thick-scaled bulb. Fruit: Cylindrical to egg-shaped capsule, 2-4 cm; Seed: Flat, triangle to tear shaped seed, golden yellow with darker centre, 4-7 mm, raised welts on surface.

***Lilium philadelphicum* – an herbaceous perennial of the boreal forest.**



***Lilium philadelphicum* a. flowering stem b. below ground corm and roots c. seed capsule d–e. seed f–g. pollen**

Habitat and Distribution

Lilies are most often found in clearings in woodlands, prairies, roadside, and meadows. Lilies take advantage of margins, such as those resulting from forestry cut lines and road building. Somewhat shade intolerant.
Seral Stage: Late seral, although establishing in margins, lily is one of the later species to invade.

Soils: Sandy to loamy, well-drained soils, more tolerant of higher pH than lower.
Distribution: Scattered in the Rocky Mountains, boreal forest and parkland in Alberta; se BC to w Que, s to NM, ND, Mich, Ohio.

Phenology

Blooms open in June-July. Stems and seeds ripen in August and September.

Pollination

Swallowtail and monarch butterflies, as well as sweat bees have been observed as pollinators (Lawrence and Leighton 1999). It is also pollinated by wind (Cook 1988).

Genetics

2n = 24

Symbiosis

Vesicular-arbuscular mycorrhizae (Currah and Van Dyk 1986).

Seed Processing

Collection: Ripe stems detach easily from bulb.
Seed Weight: 1.200-2.597 g/1000 seeds (1.887 avg).
Harvest Dates: Late July-early August.
Cleaning: Air-dry fruits at ambient temperature. If capsules are intact, merely open capsules and empty seeds. Otherwise crush material or remove large chaff and crush remaining material. Sieve to remove seeds from chaff using appropriate size screens. Small chaff and dust can be removed by winnowing.
Storage: Seed should be stored dry.
Longevity: Seed viable for at least 2 years

Propagation

Germination: 90% germination in 30 days, fresh, 1 or 2 year old seed in northeastern Alberta.
Pre–treatments: 30 days stratification (2-4°C).
Direct Seeding: Seeds sown directly into reclaimed soils in northeastern Alberta emerged well and matured to become reproductive.
Seeding Rate: 200 seeds/m² to obtain 2 plants/m².
Vegetative Propagation: Using undamaged scales of underground bulb. Dispersed by mice and small rodents when they dig the bulbs for food.

Aboriginal/Food Uses

Tubers can be eaten fresh or dried; root as part of a compound medicine can treat heart problems; boiled tubers eaten as a soup can treat appendicitis; and a dried tuber placed in a tooth cavity then crushed can relieve toothaches.

Wildlife/Forage Usage

Wildlife: Bulb scales may be eaten by rodents and other small mammals. Grizzly bears also feed on lily bulbs. Utilized by a variety of other wildlife species although of little forage value.
Livestock: Fair forage value (Gerling *et al.* 1996).
Grazing Response: Not able to withstand heavy grazing.

Reclamation Potential

May establish on margins of wooded areas.

Commercial Resources

Availability: Not widely available but some producers exist in Alberta.
Uses: Horticultural.

Notes

Prolific seed producer. Genetic diversity is maintained by fire, which releases dormant bulbs, lowers competition with other plants and removes cover for small mammals therefore reducing the rate of grazing and the rate of seedling establishment (Lawrence and Leighton 1999)

Photo Credits

Photo 1: Glen Lee, Regina Saskatchewan
Line Diagram: John Maywood, used by permission of Bruce Peel Special Collections, University of Alberta.

Scientific Name: **Family:** *Lamiaceae*
Mentha arvensis L.
Common Names: wild mint, field mint

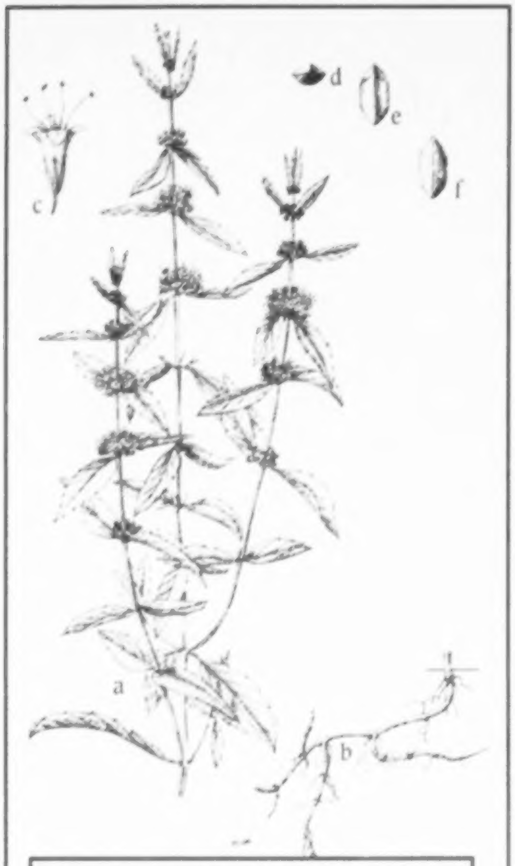
Plant Description

Aromatic, erect perennial herb, with pubescent square stems, 15-50 cm high; leaves short-petioled, opposite oblong-lanceolate to ovate lanceolate, 1-8 cm long, serrate, rounded at base; pink to pale purple or white small flowers in dense axillary clusters, corolla 4-6 mm long fused into 4-5-lobed tube.

Fruit/Seed: Four small, ovate nutlets at base of calyx, brown, ovoid, triangular at base, basal crescent-shaped depression.

Mentha arvensis **showing axillary clusters of flowers.**

Habitat and Distribution



Mentha arvensis. **a. flowering stems with opposite leaves, b. rhizome and roots, c. individual flower, d–f. seeds.**

Common in sloughs and wet places, stream banks, lakeshores, wet meadows, clearings, marshy grounds, and throughout the prairies.

Soil: Tolerates periods of flooding (Gerling *et al.* 1996).

Distribution: Widespread across Alberta and much of North America and Eurasia. Circumboreal and circumpolar.

Phenology

Flowers in June to July (Currah et al. 1983).

Pollination

Insect.

Genetics

2n=12, 24, 48, 64, 72, 90, 92, 96, 120, 132

Symbiosis

Inoculation of vesicular–arbuscular mycorrhizal (VAM) fungus Glomus fasciculatum significantly increase the productivity of wild mint (Gupta et al. 2002).

Seed Processing

Collection: hand–picking of fruiting stems.
Seed weight: 0.099 – 0.106 g/1000 seeds
Harvest Dates: June and late August
Cleaning: Air-dry fruiting stems in paper or Tyvek bags at 15-25°C. Crush material or remove large chaff and crush remaining material. Sieve to remove seeds from chaff using appropriate size screens. Small chaff and dust can be removed by winnowing.
Longevity: Up to 6 years

Propagation

Natural Regeneration: Rhizomes regenerate shoots from their nodes (Bahl *et al.* 2002).
Pre–treatments: Germination increases if cold stratified for at least 4 weeks. Thompson *et al.* (1977) suggest that a 4.5°C fluctuating temperature is required to promote germination under light.
Vegetative Propagation: Regenerates primarily by rhizomes. 90% of rhizomes survived the first year and fully established by year three. *Mentha arvensis* spreads in wetlands. Propagates by rhizome cuttings or division of plants in spring or fall; by tip cuttings in spring, if cuttings placed in sand or vermiculite under intermittent mist or in heated frames, they will root in 21 to 28 days (Currah *et al.* 1983). Cold stored suckers can serve as direct sowing material for the late summer crop of mint (Bahl *et al.* 2002).

Aboriginal/Food Uses

Food: Mint tea is made by boiling the leaves.
Medicinal: Tea can be taken to treat a cough, a cold, congestion, fever, chills, menstrual cramps, to soothe teething babies' gums, to treat tiredness or fatigue, to aid with digestion, to treat children's diarrhea, to treat headaches and to treat high blood pressure. Also, part of a compound medicine to treat cancer or diabetes, or pain, and used as a wash for sores. Flowers can be grinded and mixed with yarrow and water to use as a wash for infected gums or to relieve a toothache.

Divisions or cuttings showing shoot and rhizome with some roots.

Commercial Resources

Availability: Available through a few nurseries in Alberta and Manitoba.
Cultivars: Available cultivars are not suitable for reclamation needs.
Uses: Industrial crop used for the production of menthol for use in cosmetic, pharmaceutical, food, and flavouring industries (Gupta *et al.* 2002).

Photo Credits

Photos: Wild Rose Consulting, Inc.
Line Diagram: John Maywood, used by permission of Bruce Peel Special Collections, University of Alberta

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Appendix G—Planting Prescriptions on Reclaimed Landscapes Receiving LFH Amendments

Overview

Establishment of woody plant species on reclaimed landscapes in the AOSR historically relied on out-planting desired species and expected the remainder of species to establish naturally. Utilizing the LFH layer and upper 10 to 30 cm of upland forest soils as a source of propagules has proved to be successful in establishing woody plants on experimental plots on reclaimed landscapes, as indicated from current research in the AOSR (MacKenzie 2009; Mackenzie and Naeth 2007; Mackenzie 2006). In the past, salvaging upland surface soils in the AOSR was not mandated. Now, various oil sands operators are required to salvage all upland surface soils because of its value as a surface soil and source of propagules; however, some operators are not required to salvage their upland surface soils for reclamation. Stakeholders including Government and the Soil and Vegetation Sub-Group want to provide incentives for operators to salvage this material, meaning that fewer trees and shrubs would require planting. A revised tree and shrub planting prescription is presented for reclaimed landscapes that receive properly handled LFH amendments.

Clarification of Terminology

There is a need for clarification of the terminology used when salvaging upland forest soils for reclamation because inconsistent use of terms can lead to confusion, resulting in poor handling procedures. Various terms are used by different professions to describe the organic layer or soils being salvaged from upland plant communities. Common terms used to describe the organic layer include duff, forest floor, litter layer, mull and LFH. Regardless of the term used, all are relating to the organic horizon developed from litter accumulation on upland forests. Particular terms such as FH, duff and mull describe the litter as being decomposed to some particular degree. LFH is the desired term for describing the organic layer, as it distinguishes its origin between upland forests and lowland forests; it is also used and defined within the Canadian System of Soil Classification, and this term is currently used by practitioners. LFH means the forest floor that accumulates on the mineral soil surface under forest vegetation that developed primarily from the accumulation of leaves, twigs, and woody materials with or without a minor component of mosses (Agriculture Canada Expert Committee on Soil Survey 1987). The LFH horizons are usually not subject to prolonged periods of water saturation.

Previous soil salvage projects describe salvaging upland surface soils as "shallow soil salvage", without including the description of the organic layer, depth of salvage or salvage location. The two latter descriptions should be stated because they can affect the quality and management of the material being salvaged. The description of the organic layer helps to clarify peat is not included. Using a term with LFH alone can be misinterpreted and biased in the salvage program. Salvaging the LFH layer separate from the upper 5 to 30 cm of mineral soil is not effective on a large scale and might not be desired from a revegetation standpoint. Placement of LFH only onto reclaimed landscapes can result in a loose substrate that is susceptible to drying out, leading to a high mortality of roots and creating unfavourable conditions for seed germination. The most suitable term for inclusion of the LFH layers and the upper 10 to 30 cm of mineral soil is upland surface soils. Upland surface soils consist of the LFH layers and part of or the entire A horizon. The thickness of the A horizon will determine if the entire horizon requires salvage.

Once upland surface soils are salvaged, pushed into windrows, placed into stockpiles or applied to a reclaimed landscape, the desired term to use is LFH amendment. The term LFH amendment replaces upland surface soils because, once soil has been intensively altered and moved from its original location, it is no longer considered a soil as per the Canadian System of Soil Classification. The term LFH implies the source location of organic material is from an upland forest, and amendment (in the context of this document) implies the mixture of LFH and A horizon is an improvement to reclaimed landscapes. The ecosite from the location the LFH amendment was salvaged must be stated before or after the term LFH amendment; this will assist in determining where it should be placed on the reclaimed landscape. Plant species from the salvage location should be adapted to similar soil moisture and nutrient regimes on the target ecosite on the reclaimed landscape.

The primary use for LFH amendments is to provide a source of plant propagules on reclaimed landscapes and salvage and handling plans should focus on maintaining the viability of propagules rather than general soil quality parameters, because the viability of propagules is more susceptible to degradation compared to nutrient concentrations and physical properties within the amendment. Additionally, improvements to soil quality through nutrient additions and physical manipulation in the future are easier from an operational standpoint versus having to collect seeds, grow and transplant seedlings.

Literature Review of Revegetation using LFH Amendments

Since 1997, CONRAD, CEMA and various oil sands companies have funded research assessing the effects of the addition of LFH amendment on native plant establishment and diversity on various experimental plots on reclaimed landscapes in the AOSR. The majority of studies have been successful in increasing the abundance and diversity of upland plant communities. For most herbaceous plant species, those that are present at the upland donor site will establish successfully at the receiving site, providing similar moisture and nutrient regimes are established. The success of establishing woody plant species from in situ propagules within the LFH amendment is variable. Initial establishment from woody plant species is dominantly from plant vegetative parts and factors most affecting the survivability and abundance of plant vegetative parts will govern the initial success of establishment. For most sites, it is anticipated that establishment from seeds will have more of an influence a few years after LFH amendments are placed. The remaining portions of this section describe the research sites, results or preliminary results on woody plant establishment and factors that lead to poor or good establishment.

Syncrude Canada Ltd. and Suncor were the first to attempt to utilize LFH amendments as a propagule source for revegetating reclaimed landscapes in the AOSR (AMEC 2005; Lanoue and Qualizza 1999). The Suncor LFH amendment study was established in 2000 at the Steepbank North Dump and four surface soil caps were compared, including a peat-mineral mix, 5 cm spread of LFH amendment over peat-mineral mix, 20 cm spread of LFH amendment over secondary mineral soil and a mix of 30 to 40% LFH amendment with 60 to 70% peat-mineral mix. LFH amendments were salvaged from d ecosite surface soils at an average depth of LFH plus 20 cm of mineral soil. In summary, the LFH amendments that were not mixed with peat-mineral mix had a greater canopy cover of woody plants versus the other treatments, and the 20 cm application depth had the highest cover. No density data was recorded for the Suncor LFH study.

Objectives of the Syncrude pilot project were to assess the effects of the addition of LFH amendment on native species establishment and compare seasonal effects of application (summer versus winter placement) on a tailings dyke. Upland surface soils from a d ecosite were salvaged to an average depth of 7.8 cm in late August 1999. Summer application treatments had LFH amendment applied shortly after salvaging, and the winter placed LFH amendment was left in windrows until required for placement in January 2000. LFH amendments were applied at depths ranging from 11 cm to 18 cm. The raw data from Syncrude's first year data set was extrapolated to woody stems per hectare. No long-term data were provided; therefore, densities for the first year of establishment are presented. LFH amendments applied during the summer had densities ranging from 10,100 to 26,000 stems ha^{-1}, with an average density of 17, 233 stems ha^{-1}. Fewer woody species established when the LFH amendment was stored in windrows and placed in January 2000; the average densities ranged from 3,450 to 4,800 stems ha^{-1}, with an overall average density of 4,250 stems ha^{-1}. No woody species established in the treatments that had no LFH amendment added. Trembling aspen and balsam poplar only established in summer application treatments; stem densities ranged from 0 to 2,200 stems ha^{-1} with an average density of 1,010 stems ha^{-1}. Wild rose and snow berry were the most abundant shrubs; other shrubs present include Saskatoon berry, red-osier dogwood and blueberry. In summary, woody species established successful from in situ propagules within the LFH amendment. Greater densities were present in the direct placed treatment.

Mackenzie (2006) and Mackenzie and Naeth (2007) established studies to test the effects of LFH amendment application depth on native species establishment. The research was conducted on a south-east aspect on a saline-sodic overburden dump with 90 cm of secondary mineral soil. LFH amendments were compared to peat-mineral mix and two application depths were assessed: 13 cm and 22 cm. Upland surface soils from a d ecosite were salvaged in October 2003 at depths ranging from 12.5 to 27.5 cm; the LFH amendment was placed in small windrows until February 2004. Estimates of viable woody plant propagules within the upper 10 cm of upland surface soil were 627 ± 269 m^{-2}; 45% emerged from plant vegetative part, 45% emerged from seed and 10 % emerged from an unknown origin. The addition of LFH amendment significantly increased woody species establishment compared to peat-mineral mix treatments. Application depth had a significant effect on the success of woody plant establishment. Thick application depths had an average density of 22,600 ± 6,600 stems ha^{-1} and thin application depths had an average density of 11, 500 ± 1,600 stems ha^{-1}. Average stem densities decreased in the second growing season in both LFH amendment treatments; thick application depths had 17,000 ± 1,000 stems ha^{-1} and thin application depths had 8,000 stems ha^{-1}. However, the average stem densities significantly increased during the third growing season; thick application depths had 69,000 stems ha^{-1} and thin application depths had 20,000 stems ha^{-1}.

Within the first growing season, trembling aspen had an average density of 2,000 stems ha^{-1} and less than 1,000 stems ha^{-1} within the thick and thin application depth treatments, respectively. Both treatments had an average of 1,000 trembling aspen stems ha^{-1} in the second growing season. During the third growing season, the average stem densities were 250 stems ha^{-1} within the thick treatment and 1000 stems ha^{-1} within the thin treatment. Balsam poplar established within the thin treatments only, and the average density was 200 stems ha^{-1}. Three shrubs contributed over 80% to the total average density during each growing season - these were wild red raspberry, prickly rose and currants. Other woody plants that established included kinnikinnick, white birch, bog birch, red-osier dogwood, three-toothed cinquefoil, snow berry, blueberry and willow. By the third growing season, the majority of shrubs had started to produce seed. In summary, addition of LFH amendment regardless of the application depth increased woody plant establishment compared to the peat-mineral mix treatment. Thick application depths had greater densities. Many factors could have contributed to better establishment rates within the thick application depth treatments; however, greater available soil moisture and better root to soil contact are likely the main factors.

Mackenzie and Naeth have established several other experiments utilizing LFH amendments. One experiment assessed the effects on native plant establishment from LFH amendment placed at different patch sizes and at different slope positions (unpublished data Mackenzie and Naeth 2008). The experiment was established at the Syncrude Canada Ltd. Base Mine on a saline sodic-overburden dump that received 80 cm of secondary mineral soil on a north aspect. Upland surface soils were salvaged from a d ecosite to a depth that did not exceed 2 to 5 cm below the LFH layer. The experiment was established in winter 2005 and has been monitored for three growing seasons. Preliminary results from the first growing season show total woody stem densities ranging from approximately 30,000 stems ha^{-1} to 110,000 stems ha^{-1}, with a combined average of approximately 89,000 stems ha^{-1}. During the third growing season, total woody stem densities ranged from 77,000 to 100, 000 stems ha^{-1}, with an average density of 93,000 stems ha^{-1}. Greater densities were found on larger patches, lower slope positions and on locations where LFH amendments were not saturated with water. The dominant woody species after the third growing season (over 85% of total densities) were wild red raspberry, prickly rose and currants. Trembling aspen did not establish well for the majority of the treatments; stem densities ranged from approximately 0 to 3,000 stems/ha within each growing season. The average aspen stem density during the third growing season was 1400 stems ha^{-1}. Balsam poplar had an average density of 300 stems ha^{-1}, and it was only present during the third growing season. Other woody plant species that established were similar to those found in Mackenzie (2006).

Mackenzie (unpublished data 2009) established an experiment that assessed the effects of salvage depth (10 cm vs. 25 cm) of upland surface soils from a and b ecosites and application depth (10 cm vs. 20 cm) of LFH amendments on a lean oil sands overburden dump at the Syncrude Canada Ltd. Aurora North Mine. Two separate experiments were set up on different substrates on a north aspect, one experiment with a 1 m layer of sand and the second with a 1 m layer of peat-sand mix. Controls consisted of peat-sand substrate without LFH amendment for comparison. LFH amendments applied on the peat-sand substrate were salvaged mostly from an a ecosite and LFH amendments on the sand substrate were salvaged from a b ecosite. Within the first growing season, the total woody stem densities ranged from 22,000 stems ha^{-1} to 92,000 stems ha^{-1} among all of the treatments. The average total stem density increased in the second growing season for the majority of the treatments at both experiments. Within the second growing season the average stem density ranged from 36,000 stems ha^{-1} to 96,000 stems ha^{-1}. No woody plants established on the control treatment; however, after the first growing season, very few woody plants were present. Stem densities were greatest on treatments with LFH amendments from the b ecosite. Results after two growing seasons indicate salvage depth has little effect on the established total stem density, regardless of the ecosite from which the surface soil was salvaged. Application depth had a substantially greater effect on densities of total stems established. Regardless of the ecosite the LFH amendments were salvaged from, the treatments that were applied at 20 cm had more than 30,000 stems ha^{-1}, compared to the treatments receiving 10 cm of LFH amendment. All woody species that were present at the donor site established at the receiver sites. The majority of shrubs established include green alder, Saskatoon berry, kinnikinnik, pin cherry, prickly rose, wild red raspberry, snow berry, blueberry, bog cranberry, trembling aspen and jack pine. There was over 1000 stems ha^{-1} established in each treatment for the following species: kinnikinnik, pin cherry, prickly rose, blueberry and trembling aspen. The density of jack pine increased in 2007. After the second growing season, the average jack pine densities ranged from 0 to 1400 stems ha^{-1} and the lowest densities were found in treatments that received LFH amendments from a thick salvage depth. In summary, the addition of LFH amendment salvaged from a and b ecosites provide woody plants in greater abundance than treatments not receiving LFH amendments. Salvage depth does not have as great an effect on the success of establishment as application depth.

Mackenzie (unpublished data 2009) researched the effects of stockpiling on the viability of seeds and roots from various boreal forest species. Factors assessed include stockpile size, burial depth and storage time. Four large and small stockpiles were established at various mines within the AOSR. Large stockpiles were built at a scale that would represent a main storage site for LFH amendments, while small stockpiles represented the size of a typical windrow. Three replicates of each stockpile size were built from LFH amendment developed on coarse textured soils, and the other set was constructed from fine textured soil. One set from the coarse textured stockpiles was constructed in the winter and the remaining sets were constructed in mid to late fall. Ten shrub species and one tree species had seeds buried within each stockpile at different depths ranging from near surface to the bottom of the stockpile. Three shrub species also had root cuttings buried. Preliminary results indicate after a short storage period (8 months), the majority of seeds and roots do not retain their viability when buried at depths below 1 m from the surface of large stockpiles. The viability of seeds and roots are less affected when buried in small stockpiles; however, after 12 months of storage, effects are just as detrimental as stockpiling in large piles. Stockpiling LFH amendments when surface soils are salvaged in the winter have fewer impacts to the viability of seeds compared to those constructed in the fall; however, after 12 months of storage, effects are similar to stockpiling in non-frozen conditions. It is anticipated that loss of viability of seeds and roots occurs faster when LFH amendments developed from fine textured soils are stockpiled.

Mackenzie and Naeth are currently investigating the potential of utilizing LFH amendments as inoculants. The fact that LFH amendments are an invaluable source of propagules to the AOSR, means all that can be utilized for revegetation has to be maximized. LFH amendments applied at depths 10 cm and greater within time will become a suitable surface soil once plant communities are self sustaining. Providing the reclaimed surface soils developed from peat-mineral mixes or suitable mineral soils are suitable for plant establishment, LFH amendments may be more appropriately utilized if spread at 5 cm or less over top of the peat-mineral mix. Conclusions and recommendations from this study will be provided in the near future.

Literature Review of Woody Stem Densities from Various Natural and Managed Forested Ecosystems

Woody stem densities vary widely in boreal forest ecosystems that have been naturally disturbed, received silviculture prescriptions or left undisturbed. Understanding factors that regulate the reestablishment of woody species in more natural settings and having general ranges and averages of their densities in comparison to stem densities established from LFH amended landscapes will help land managers to prescribe a particular planting prescription more accurately.

Stem density in a clear cut trembling aspen stand 21 years after harvest for coniferous trees and shrubs and deciduous trees and shrubs were 209±34 stems ha^{-1}, 1,200±400 stems ha^{-1}, 2,327±144 stems ha^{-1} and 33,280±800 stems ha^{-1}, respectively (Hobson and Bayne 2000). Within the same region, a mature (54 year) trembling aspen stand disturbed by fire had stem densities of 40±15 stems ha^{-1}, 400±400 stems ha^{-1}, 688±66 stems ha^{-1} and 57,200±10,800 stems ha^{-1} for coniferous trees and shrubs and deciduous trees and shrubs, respectively. Stem densities, in an old (90 year) trembling aspen stand previously disturbed by fire, for coniferous trees and shrubs and deciduous trees and shrubs were 71±20 stems/ha and 400±400 stems ha^{-1} and 335±40 stems ha^{-1} and 24,400±5600 stems ha^{-1}, respectively.

Shrub stem densities from twelve partially harvested upland forested stands in northeastern Alberta varied from 15,500±1610 to 27,900±1653 stems ha^{-1} (Hannon et al. 2002). From the twelve upland forested stands assessed, the majority of the average stem densities were within the range of 20,000 to 23,000 stems ha^{-1}. No soil descriptions or ecosite types were present for comparisons and there was no distinct trend in shrub densities from the percent forest harvested. Regenerating tree stem densities within burned and harvested mixedwood forest stand in northeastern Alberta ranged from 2,100±500 to 87,800±70,000 stems ha^{-1} (Hobson and Shieck 1999). Tree stem densities were greater in 1 year old stands compared to the 14 year old and 28 year old stands after disturbance. The youngest stand after tree harvesting had 14,700±3,800 stems/ha.

Tree and Shrub Planting Densities on LFH Amended Landscapes

The first edition of the Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (OSVRC 1998; Revegetation Manual) recommended prescribed planting density ranges for trees and shrubs which were consistent for all the ecosite phases and only species composition changed (OSVRC 1998). Tree planting densities of 1800 to 2200 stems ha^{-1} and shrub planting densities of 500 to 700 stems ha^{-1} were recommended for a combined total density of 2,000 to 2,500 stems ha^{-1}. This planting density range was chosen to ensure the adequate stocking of each species after initial mortality was accounted for, and also allowed for the volunteer establishment of shrubs and trees from native seeds and root fragments present in the amendment materials (OSVRC 1998). A planting rate of 2,500 seedlings ha^{-1} has been recommended and consistently used by Suncor (Tuttle 1997), although rates of up to 5,000 stems ha^{-1} have been used. Spacing typically ranges from 0.5 to 2 m between individual seedlings.

In Section 4.5 of this version of the Revegetation Manual, the understory species planting density range is consistent with that recommended in 1998 with additional guidance provided regarding characteristic species by target ecosite and contributions to establishment densities from LFH amendments. The expected contributions to overstory and understory densities from LFH amendments are summarized in Figure 4-2 in Section 4.5.6. The expected contributions are based on salvage, storage and placement techniques that are aimed at maintaining propagule viability. These contributions have been developed for landscapes that receive a minimum of 10 cm of LFH amendment that have been salvaged from surface soils to a depth no greater than 30 cm. Reclaimed landscapes that receive greater than 10 cm of LFH amendment and surface soils, including the LFH layer, that have been salvaged at shallower depths will provide greater densities of woody plants and the canopy cover will also be greater. Benefits from the propagule bank are greatest when LFH amendments are directly placed versus stockpiled. Expected contributions to establishment densities for coniferous trees will only be used for upland surface soils salvaged from a and b ecosites. A more conservative stocking rate should be used on drier aspects. White spruce is not a seed banking species, and its contribution to the propagule bank in the LFH amendment is limited to masting years; therefore, it is not included within the prescription. Both jack pine and black spruce maintain a seed bank, aerially and near the surface soil; however, data has only been collected for jack pine. Operators are encouraged to salvage cones from jack pine and black spruce stands as a seed source for reclaimed landscapes. Longer term data and additional research will be required to make a more accurate estimate of contributions to establishment densities for these trees.

The species that establish through natural recovery will be dependant on the above ground plant species that existed prior to soil salvaging, the species abundance and composition of the seed bank. If additional planting is required after placement of LFH amendments, only species that have not successfully established will require planting. The target tree and shrub species selected for planting are listed in Table G.1. Table G.2 summarizes the relative densities for each tree and shrub species that have established at the research sites Mackenzie and Naeth have established within the AOSR. The table lists each species' approximate densities found at a, b and d ecosites prior to soil salvaging and after placement. The densities provided for the research sites are from sites with a minimum of two growing seasons of data collection. Monitoring tree and shrub establishment within the first two to three years will be required to ensure that trees and shrubs establishing from natural recovery from the LFH amendments are providing the desired densities. If not, additional planting may be required. The table has been provided to help planners decide if additional species require planting on sites that receive LFH amendment; not all woody plants establish successfully after surface soils have been intensively handled.

Monitoring – Established Woody Species

Many uncertainties in a revegetation program can limit the success of plant establishment, due to various environmental and operational factors. Factors determining the success of reestablishment of targeted woody species from LFH amendment material include species sensitivity to disturbance, species composition at the salvage site, proportion of herbaceous species within the propagule bank, disturbance history, salvage and placement, placement techniques, storage time, soil texture, winter temperatures and available soil moisture. The most important factor determining the success of woody plant establishment from seeds and plant vegetative parts is soil moisture. A dry spring and summer within the first year of placement can result in over 80% mortality of plant vegetative parts. Monitoring within the first two to three years will be required to determine if the minimum planting densities for trees and shrubs was achieved. Monitoring in the second year is preferred because it allows operators to assess the abundance of herbaceous species competing for available resources.

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Table G.1 Woody species selected for planting by ecosite phase

Landscape Features	Soil Capability and Moisture Regime	Target Ecosite Phase	Tree Species[a] (Total Density of 1800-2200 Stems/ha)	Shrub Species[a] (Total Density of 500-700 Stems/ha)
Tailings Sand, Crests	Soil Class 4, Xeric, Subxeric	a1 lichen, jack pine	jack pine	blueberry, bearberry, green alder
Tailings Sand Slope, South Aspect	Soil Class 4-3, Subxeric, Submesic	b1 blueberry, jack pine-aspen	jack pine aspen white spruce	blueberry, bearberry, Labrador tea, green alder
Tailings Sand Slope, North Aspect	Soil Class 3-2, Subxeric, Submesic	b2 blueberry, aspen (white birch)	aspen white birch white spruce	blueberry, bearberry, Labrador tea, green alder
		b3 blueberry, aspen-white spruce	aspen white birch white spruce	blueberry, bearberry, Labrador tea, green alder
		b4 blueberry, white spruce-jack pine	white spruce jack pine	blueberry, bearberry, Labrador tea, green alder
Overburden, Low Organic	Soil Class 3, Mesic, Submesic	c1 Labrador tea (mesic), jack pine-black spruce	jack pine black spruce	Labrador tea, green alder, bog cranberry, blueberry
Overburden, South Aspect	Soil Class 3-2, Mesic	d1 low-bush cranberry, aspen	aspen white spruce balsam poplar white birch	low-bush cranberry, Canada buffalo-berry, saskatoon, green alder, rose, raspberry
Overburden, North Aspect	Soil Class 3-2, Mesic	d2 low-bush cranberry, aspen-white spruce	aspen white spruce balsam poplar white birch	low-bush cranberry, Canada buffalo-berry, saskatoon, green alder, rose, raspberry
Overburden, North Aspect	Soil Class 3-2, Mesic, Subhygric	d3 low-bush cranberry, white spruce	white spruce aspen balsam poplar white birch	low-bush cranberry, Canada buffalo-berry, saskatoon, green alder, rose, raspberry
Near Level Overburden or Tailings Sand	Soil Class 3-2, Subhygric, Mesic	e1 dogwood, balsam-aspen	aspen balsam poplar white spruce white birch	dogwood, low-bush cranberry, raspberry, green alder, rose
Near Level Overburden or Tailings Sand	Soil Class 3-2-1, Subhygric, Mesic	e2 dogwood, balsam-white spruce	white spruce aspen balsam poplar white birch	dogwood, low-bush cranberry, raspberry, green alder, rose
		e3 dogwood, white spruce	white spruce aspen balsam poplar white birch	dogwood, low-bush cranberry, raspberry, green alder, rose
Near Level Overburden or Tailings Sand, Lower Slope Position	Soil Class 2-1, Subhygric	f1 horsetail, balsam-aspen	balsam poplar aspen birch white spruce	rose, green alder, dogwood, raspberry, low-bush cranberry
		f2 horsetail, balsam-white spruce	white spruce aspen balsam poplar birch	rose, dogwood, low-bush cranberry
		f3 horsetail white spruce	white spruce	rose, low-bush cranberry

[a] In general, species are listed in order of dominance to be planted in the target ecosite phase

Table G.2 **Approximate density (stems ha^{-1}) classes of trees and shrubs found on pre-mined areas and reclaimed research ecosites**

Species	**Pre-mined Areas**			**Reclaimed Research Areas**		
	Ecosite			**Ecosite**		
	a	**b**	**d**	**a**	**b**	**d**
Trees						
Balsam poplar		•	•••			••
Black spruce			•			
Jack pine	••••	••••		•••	•••	
Trembling aspen	••	••••	••••	••	••••	•••
White birch			••			•
White spruce		••	••••			
Shrubs						
Blueberry	••••	••••	•	••••	••••	•
Bog cranberry	••	•••	••			
Bracted honeysuckle		•	•		•	•
Current			••••			••••
Buckbrush	••	•••	••		••	•
Canada buffalo-berry		••	•••			
Dwarf birch						•
Green alder	••••	••••	•••	•••	•••	••
Bearberry	••••	••••	••	••••	••••	•
Low-bush cranberry		•	•••			•
Pin cherry	••••	••••		••••	••••	
Prickly rose	••••	••••		••••	••••	••••
Red-osier dogwood			••			•
Saskatoon berry	••••	••••	••	••••	••••	••
Shrubby cinquefoil			•			
Small bog cranberry			••	•	•	
Twin-flower		•••	••••			
Wild red raspberry	•	••	••••	•	••	••••
Willow		••	•••		•	••

Rarely - 1 to 10 stems ha	•
Sparse - 10 to 100 stems ha	••
Moderate - 100 to 500 stems ha	•••
Abundant - >900 stems ha	••••

Appendix H—Seed Zones, Sources and Regulations

Seed Collection and Deployment

Populations of forest species exhibit genetic variation associated with difference in geography and climate of origin. Such variation is the result of evolutionary process and is the key to biological adaptation to regional habitat and to maintainenance of future evolutionary potential. Therefore, movement and collection of all tree seed for reforestation sites is regulated and should conform to the Standards for Tree Improvement in Alberta Manual (2005) (Figure H.1). No comprehensive legislation or formal government policy about using native plant material exists in Alberta; however, the Native Plant Revegetation Guidelines (Government of Alberta, Sustainable Resources Development, 2001) provides consistent direction about how native plants are collected and used in revegetation.

The original collection site of native plant material should be as close as possible to the disturbed area or deployment site. The Native Plant Revegetation Guidelines suggest that, at a minimum, native plant material should be collected in the same Natural Region and deployed in a Natural Subregion that contains similar pre-disturbance plant communities; however, plant material collection and deployment within the same seed zone is encouraged to maintain local adaptations of particular plant species.

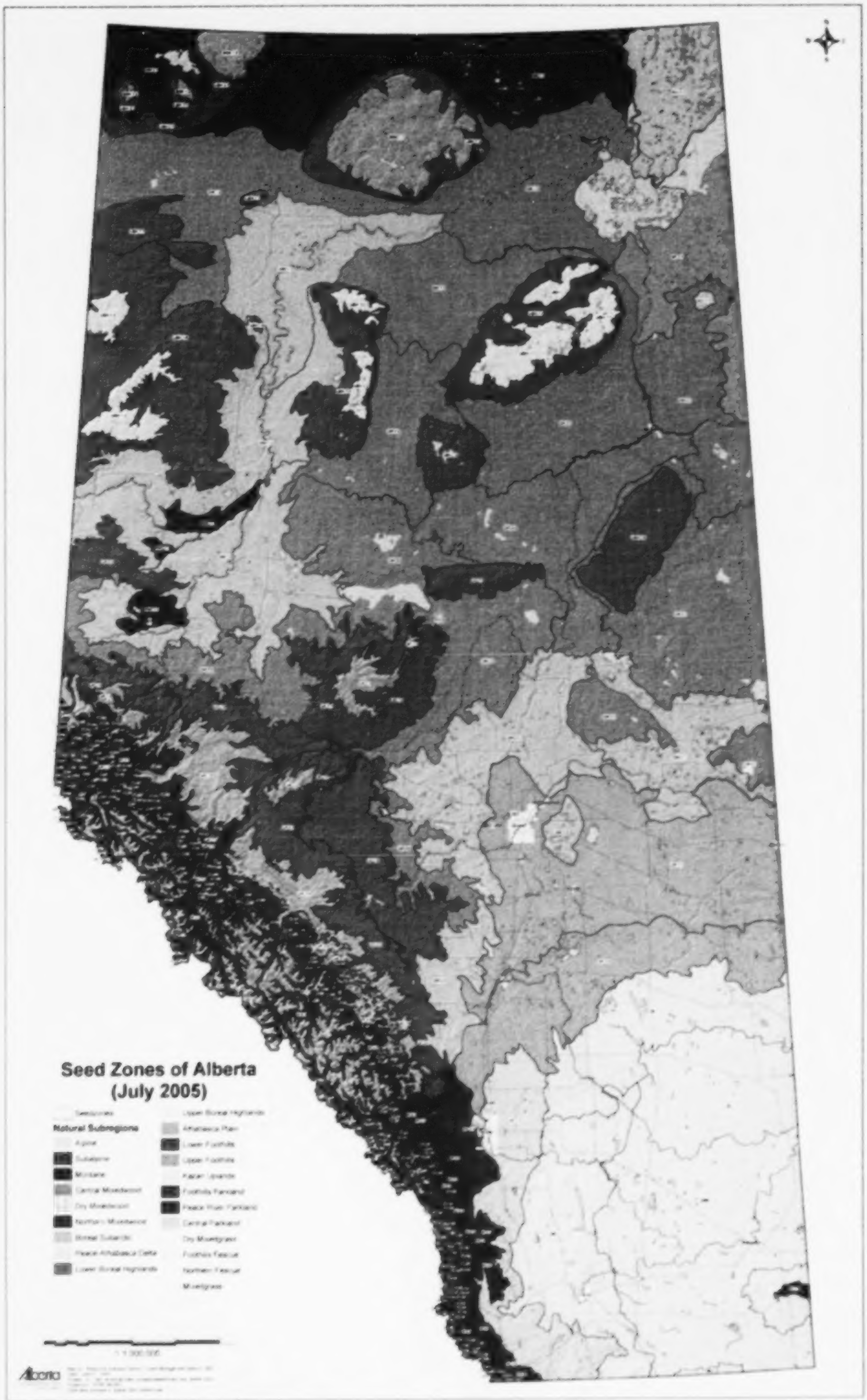
Seed Zones of Alberta
(July 2005)
Seedzones
Natural Subregions
Alpine
Subalpine
Montane
Central Mixedwood
Dry Mixedwood
Northern Mixedwood
Boreal Subarctic
Peace-Athabasca Delta
Lower Boreal Highlands
Upper Boreal Highlands
Athabasca Plain
Lower Foothills
Upper Foothills
Kazan Uplands
Foothills Parkland
Peace River Parkland
Central Parkland
Dry Mixedgrass
Foothills Fescue
Northern Fescue
Mixedgrass
Alberta

Figure H.1 Seed Zones of Alberta

Appendix I—List of Species in the Oil Sands Region

Introduction

Data used are described in the vegetation data synthesis (GDC and FORRx 2008, Table 2.1 and GDC 2009). Most data sets provided plots for ecosite a to e, and only two sources, Ecological Site Information System and the Saskatchewan field guide, had plots for ecosites f, g, and h. However, unlike ecosites a to e, differences in the moisture regime and nutrient regime edatope grid positions, and in plant community composition, precluded direct use of the Saskatchewan plot data for ecosites f, g, and h. Additional plot data used to supplement the dataset was provided by Connacher Oil and Gas Ltd., Laricina Energy Ltd., and Sunshine Oilsands Ltd.

Table I.1 shows the plot data distribution by ecosite and age classes, with age of the oldest measured plot for each ecosite. The percent of occurrence for a species in the species list table was calculated as number of plots in which the species are present divided by total plot number for an ecosite times 100.

Table I.1 Plot data distribution by ecosite and age classes

Ecosite	Age class	Max. age	Plots
A	10-20 yrs		1
A	20-30 yrs		6
A	30-40 yrs		5
A	40+ yrs	137	35
B	0-5 yrs		5
B	10-20 yrs		4
B	20-30 yrs		24
B	30-40 yrs		6
B	40+ yrs	123	25
C	10-20 yrs		1
C	20-30 yrs		1
C	40+ yrs	165	17
D	0-5 yrs		3
D	6-10 yrs		5
D	10-20 yrs		53
D	20-30 yrs		21
D	30-40 yrs		18
D	40+ yrs	170	146
E	0-5 yrs		2
E	6-10 yrs		5
E	10-20 yrs		19
E	20-30 yrs		6
E	30-40 yrs		2
E	40+ yrs	152	24
F	0-5 yrs		1
F	40+ yrs	163	58
G	0-5 yrs		5
G	40+ yrs	127	37
H	0-5 yrs		2
H	40+ yrs	115	23

The following series of tables provide total species lists for the oil sands region and for ecosties a through h in the oil sands region.

Table I.2 List of species found in the Oil Sands Region with percent occurrence. Total plots = 560

Scientific name	Common name	Per cent occurrence
Tree Stratum		
Abies balsamea	balsam fir	18.53
Betula glandulosa	bog birch	1.05
Betula occidentalis	water birch	0.17
Betula papyrifera	white birch	37.94
Betula pumila	dwarf birch	0.87
Larix laricina	tamarack	1.92
Picea glauca	white spruce	61.89
Picea mariana	black spruce	13.81
Pinus banksiana	jack pine	18.71
Pinus contorta	lodgepole pine	1.75
Populus balsamifera	balsam poplar	24.65
Populus tremuloides	aspen	68.18
Shrub Stratum		
Actaea rubra	red and white baneberry	15.56
Alnus incana		0.17
Alnus incana ssp *tenuifolia*	river alder	7.34
Alnus species		1.40
Alnus viridis	green alder	28.15
Amelanchier alnifolia	saskatoon	27.62
Apocynum androsaemifolium	spreading dogbane	2.62
Arctostaphylos rubra	alpine bearberry	0.52
Arctostaphylos uva-ursi	common bearberry	19.06
Berberis repens	creeping mahonia	0.17
Cornus stolonifera	red-osier dogwood	15.91
Corylus cornuta	beaked hazelnut	5.77
Empetrum nigrum	crowberry	0.70
Juniperus communis	ground juniper	0.17
Ledum glandulosum	glandular Labrador tea	0.17
Ledum groenlandicum	common Labrador tea	32.87
Linnaea borealis	twinflower	63.64
Lonicera dioica	twining honeysuckle	16.96
Lonicera involucrata	bracted honeysuckle	18.88
Oxycoccus microcarpus	small bog cranberry	1.05
Potentilla fruticosa	shrubby cinquefoil	0.35
Prunus pensylvanica	pin cherry	6.29
Prunus virginiana	choke cherry	2.97
Rhamnus alnifolia	alder-leaved buckthorn	0.52
Ribes americanum	wild black currant	0.17
Ribes glandulosum	skunk currant	3.67
Ribes hirtellum	wild gooseberry	0.17

Scientific name	Common name	Per cent occurrence
Ribes hudsonianum	northern blackcurrant	3.85
Ribes lacustre	bristly black currant	12.06
Ribes laxiflorum	mountain currant	0.70
Ribes oxyacanthoides	northern gooseberry	17.66
Ribes species		0.17
Ribes triste	wild redcurrant	23.95
Rosa acicularis	prickly rose	70.80
Rosa woodsii	common wild rose	9.09
Rubus arcticus	dwarf raspberry	2.97
Rubus chamaemorus	cloudberry	2.10
Rubus idaeus	wild red raspberry	27.27
Rubus parviflorus	thimbleberry	0.35
Rubus pedatus	dwarf bramble	0.70
Rubus pubescens	dewberry	50.87
Salix arbusculoides	shrubby willow	0.17
Salix athabascensis	Athabasca willow	0.35
Salix bebbiana	beaked willow	18.53
Salix discolor	pussy willow	1.40
Salix drummondiana	Drummond's willow	0.35
Salix glauca	smooth willow	0.17
Salix maccalliana	velvet-fruited willow	0.70
Salix myrtillifolia	myrtle-leaved willow	2.80
Salix pedicellaris	bog willow	0.35
Salix planifolia	flat-leaved willow	1.40
Salix pseudomonticola	false mountain willow	0.17
Salix pyrifolia	balsam willow	1.40
Salix scouleriana	Scouler's willow	1.75
Salix species		23.08
Shepherdia canadensis	Canada buffaloberry	21.68
Sorbus scopulina	western mountain-ash	0.17
Spiraea betulifolia	white meadowsweet	0.52
Symphoricarpos albus	snowberry	13.46
Symphoricarpos occidentalis	buckbrush	1.57
Symphoricarpos species		0.17
Vaccinium caespitosum	dwarf bilberry	1.57
Vaccinium membranaceum	tall bilberry	0.35
Vaccinium myrtilloides	common blueberry	38.64
Vaccinium myrtillus	low bilberry	0.52
Vaccinium scoparium	grouseberry	0.17
Vaccinium vitis-idaea	bog cranberry	41.26
Viburnum edule	low-bush cranberry	62.41
Viburnum opulus	high-bush cranberry	0.35

Scientific name	Common name	Per cent occurrence
Forb Stratum		
Achillea millefolium	common yarrow	17.48
Achillea sibirica	many-flowered yarrow	0.17
Agastache foeniculum	giant hyssop	0.17
Anemone canadensis	Canada anemone	0.35
Anemone multifida	cut-leaved anemone	1.75
Antennaria neglecta	broad-leaved pussytoes	0.17
Antennaria species		1.22
Aralia nudicaulis	wild sarsaparilla	40.56
Arnica cordifolia	heart-leaved arnica	0.70
Artemisia campestris	plains wormwood	0.52
Aster ciliolatus	Lindley's aster	25.35
Aster conspicuus	showy aster	10.31
Aster hesperius	western willow aster	0.35
Aster laevis	smooth aster	0.35
Aster puniceus	purple-stemmed aster	0.17
Aster species		1.40
Astragalus canadensis	Canadian milkvetch	0.35
Athyrium filix-femina	lady fern	0.70
Botrychium virginianum	Virginia grapefern	0.17
Brachyactis species		9.62
Brachythecium campestre		0.52
Brachythecium collinum		0.17
Brachythecium hylotapetum	woodsy ragged moss	0.17
Brachythecium rivulare	waterside feather moss	0.17
Brachythecium salebrosum	golden ragged moss	0.87
Brachythecium starkei		0.52
Brachythecium velutinum	velvet feather moss	0.35
Caltha palustris	marsh-marigold	0.87
Campanula rotundifolia	harebell	7.17
Capsella bursa-pastoris	shepherd's-purse	0.70
Castilleja miniata	common redpaintbrush	0.35
Castilleja species		0.17
Chimaphila umbellata	prince's-pine	0.17
Chrysanthemum leucanthemum	ox-eye daisy	0.17
Chrysosplenium iowense	golden saxifrage	0.17
Chrysosplenium tetrandrum	green saxifrage	0.17
Circaea alpina	small enchanter's nightshade	1.05
Cirsium arvense	creeping thistle	0.35
Cirsium hookerianum	white thistle	0.17
Coptis trifolia	goldthread	1.75
Corallorhiza maculata	spotted coralroot	0.87
Corallorhiza striata	striped coralroot	0.17
Corallorhiza trifida	pale coralroot	1.22
Cornus canadensis	bunchberry	73.08
Corydalis sempervirens	pink corydalis	0.17

Scientific name	Common name	Per cent occurrence
Cypripedium acaule	stemless lady's-slipper	0.52
Delphinium glaucum	tall larkspur	1.92
Diphasiastrum complanatum	ground-cedar	7.17
Disporum trachycarpum	fairybells	5.59
Disporum species		0.17
Dryopteris assimilis	broad spinulose shield fern	0.35
Dryopteris carthusiana	narrow spinulose shield fern	2.45
Epilobium angustifolium	common fireweed	57.52
Epilobium palustre	marsh willowherb	0.70
Equisetum arvense	common horsetail	25.00
Equisetum fluviatile	swamp horsetail	0.17
Equisetum hyemale	common scouring-rush	0.52
Equisetum palustre	marsh horsetail	0.35
Equisetum pratense	meadow horsetail	11.71
Equisetum scirpoides	dwarf scouring-rush	5.59
Equisetum species		1.05
Equisetum sylvaticum	woodland horsetail	26.05
Erysimum cheiranthoides	wormseed mustard	0.35
Fragaria vesca	woodland strawberry	3.15
Fragaria virginiana	wild strawberry	43.53
Galeopsis tetrahit	hemp-nettle	0.35
Galium boreale	northern bedstraw	36.89
Galium species		0.17
Galium trifidum	small bedstraw	0.70
Galium triflorum	sweet-scented bedstraw	15.91
Geocaulon lividum	northern bastard toadflax	14.16
Geranium species		0.17
Geum macrophyllum	large-leaved yellow avens	0.35
Goodyera repens	lesser rattlesnake plantain	10.31
Gymnocarpium dryopteris	oak fern	2.27
Haplopappus species		0.52
Hedysarum alpinum	alpine hedysarum	0.17
Hedysarum boreale	northern hedysarum	0.52
Hedysarum species		0.17
Heracleum lanatum	cow parsnip	1.05
Hieracium umbellatum	narrow-leaved hawkweed	3.15
Hypericum species		0.35
Lathyrus ochroleucus	cream-colored vetchling	34.09
Lathyrus venosus	purple peavine	1.40
Lilium philadelphicum	western wood lily	1.75
Listera borealis	northern twayblade	0.17
Listera cordata	heart-leaved twayblade	0.52

Scientific name	Common name	Per cent occurrence
Lycopodium annotinum	stiff club-moss	15.73
Lycopodium clavatum	running club-moss	1.92
Lycopodium obscurum	ground-pine	5.77
Maianthemum canadense	wild lily-of-the-valley	53.85
Malaxis monophylla	white adder's-mouth	0.17
Matteuccia struthiopteris	ostrich fern	0.17
Melampyrum lineare	cow-wheat	4.90
Mentha arvensis	wild mint	0.17
Mertensia paniculata	tall lungwort	46.68
Microseris nutans	nodding scorzonella	0.35
Minuartia species		0.52
Mitella nuda	bishop's-cap	38.99
Moehringia lateriflora	blunt-leaved sandwort	0.35
Moneses uniflora	one-flowered wintergreen	1.57
Monotropa uniflora	Indian-pipe	0.52
Orthilia secunda	one-sided wintergreen	26.22
Osmorhiza depauperata	spreading sweet cicely	0.35
Parnassia palustris	northern grass-of-parnassus	0.35
Pedicularis labradorica	Labrador lousewort	2.45
Petasites frigidus	arctic sweet coltsfoot	0.70
Petasites frigidus var frigidus	sweet coltsfoot	0.52
Petasites frigidus var palmatus	palmate-leaved coltsfoot	51.92
Petasites frigidus var sagittatus	arrow-leaved coltsfoot	0.35
Phacelia franklinii	Franklin's scorpionweed	0.17
Plagiobothrys species		0.52
Platanthera hyperborea	northern green bog orchid	0.70
Platanthera obtusata	blunt-leaved bog orchid	0.70
Platanthera orbiculata	round-leaved bog orchid	2.10
Polygonum convolvulus	wild buckwheat	0.17
Polygonum species		0.52
Potentilla palustris	marsh cinquefoil	0.17
Potentilla tridentata	three-toothed cinquefoil	1.75
Pyrola asarifolia	common pink wintergreen	30.94
Pyrola chlorantha	greenish-flowered wintergreen	9.79
Pyrola elliptica	white wintergreen	0.17
Pyrola species		1.40
Ranunculus acris	tall buttercup	0.17
Ranunculus lapponicus	Lapland buttercup	0.87
Ranunculus macounii	Macoun's buttercup	0.17
Sanicula marilandica	snakeroot	0.17
Saxifraga tricuspidata	three-toothed saxifrage	0.70
Scutellaria galericulata	marsh skullcap	0.17
Selaginella selaginoides	spiny-edged little club-moss	0.17

Scientific name	Common name	Per cent occurrence
Senecio indecorus	rayless ragwort	0.17
Senecio pauciflorus	few-flowered ragwort	0.17
Smilacina racemosa		0.17
Smilacina stellata	star-flowered Solomon's-seal	0.52
Smilacina trifolia	three-leaved Solomon's-seal	1.75
Solidago canadensis	Canada goldenrod	0.35
Solidago gigantea	late goldenrod	0.17
Solidago multiradiata	alpine goldenrod	0.17
Solidago nemoralis	showy goldenrod	2.45
Solidago simplex		1.75
Solidago simplex ssp *simplex*	mountain goldenrod	0.17
Solidago species		0.87
Sonchus arvensis	perennial sow-thistle	0.52
Spiranthes romanzoffiana	hooded ladies'-tresses	0.87
Stellaria longifolia	long-leaved chickweed	0.52
Stellaria longipes	long-stalked chickweed	0.17
Stellaria species		0.17
Streptopus amplexifolius	clasping-leaved twisted-stalk	0.52
Taraxacum officinale	common dandelion	4.02
Taraxacum species		0.17
Thalictrum dasycarpum	tall meadowrue	0.35
Thalictrum occidentale	western meadowrue	0.17
Thalictrum species		0.17
Thalictrum venulosum	veiny meadowrue	3.50
Thlaspi arvense	stinkweed	0.17
Trientalis borealis	northern starflower	29.20
Trientalis europaea	arctic starflower	1.40
Trifolium hybridum	alsike clover	0.52
Trifolium pratense	red clover	0.87
Trifolium repens	white clover	0.17
Urtica dioica	common nettle	0.52
Vicia americana	wild vetch	20.80
Viola adunca	early blue violet	2.10
Viola canadensis	western Canada violet	5.77
Viola nephrophylla	bog violet	0.35
Viola nuttallii	yellow prairie violet	0.17
Viola orbiculata	evergreen violet	0.35
Viola palustris	marsh violet	0.52
Viola renifolia	kidney-leaved violet	25.00
Viola species		0.52

Scientific name	Common name	Per cent occurrence
Grass Stratum		
Agropyron species		0.17
Agrostis scabra	rough hairgrass	0.17
Bromus ciliatus	fringed brome	0.52
Bromus inermis	awnless brome	0.35
Bromus inermis ssp *pumpellianus*		0.52
Bromus vulgaris	woodland brome	0.17
Calamagrostis canadensis	bluejoint	55.07
Calamagrostis inexpansa	northern reedgrass	0.70
Calamagrostis species		0.52
Calamagrostis stricta	narrow reedgrass	0.35
Carex aquatilis	water sedge	0.87
Carex aurea	golden sedge	0.17
Carex brunnescens	brownish sedge	0.35
Carex concinna	beautiful sedge	0.35
Carex cordillerana		0.17
Carex deflexa	bent sedge	0.35
Carex deweyana	Dewey's sedge	0.17
Carex disperma	two-seeded sedge	2.80
Carex gynocrates	northern bog sedge	0.52
Carex leptalea	bristle-stalked sedge	0.35
Carex norvegica	Norway sedge	0.17
Carex pauciflora	few-flowered sedge	0.17
Carex peckii	Peck's sedge	0.17
Carex rossii	Ross' sedge	0.52
Carex siccata	hay sedge	1.05
Carex species		6.64
Carex tenera	broad-fruited sedge	0.17
Carex trisperma	three-seeded sedge	0.17
Carex vaginata	sheathed sedge	2.10
Cinna latifolia	drooping wood-reed	0.17
Elymus glaucus	smooth wildrye	1.75
Elymus species		0.17
Elymus trachycaulus	slender wheatgrass	0.52
Eriophorum gracile	slender cottongrass	0.17
Festuca ovina	sheep fescue	0.17
Festuca species		0.17
Glyceria borealis	northern manna grass	0.17
Glyceria striata	fowl manna grass	0.17
Hierochloe hirta ssp *arctica*	sweetgrass	0.17
Juncus balticus	wire rush	0.17
Leymus innovatus	hairy wildrye	34.27
Luzula multiflora	field wood-rush	0.17
Oryzopsis asperifolia	white-grained mountain rice grass	3.67

Scientific name	Common name	Per cent occurrence
Oryzopsis canadensis	Canadian rice grass	0.70
Oryzopsis pungens	northern rice grass	4.55
Oryzopsis species		0.17
Phleum pratense	timothy	0.17
Poa palustris	fowl bluegrass	0.35
Poa pratensis	Kentucky bluegrass	0.17
Poa species		0.35
Schizachne purpurascens	purple oatgrass	2.80
Scirpus microcarpus	small-fruited bulrush	0.17
Typha latifolia	common cattail	0.17
Moss Stratum		
Abietinella abietina	wiry fern moss	0.17
Amblystegium riparium		0.17
Amblystegium serpens		0.35
Aulacomnium palustre	tufted moss/glow moss	8.39
Barbilophozia barbata	liverwort	0.17
Bryum pallescens		0.17
Bryum pseudotriquetrum	tall clustered thread moss	0.17
Bryum species		0.52
Calliergon cordifolium	heart-leaved feather moss	0.35
Calliergon giganteum	giant water moss	0.17
Calliergon richardsonii	Richardson's water moss	0.17
Campylium hispidulum		0.87
Ceratodon purpureus	purple horn-toothed moss	2.45
Cinclidium stygium	common northen lantern moss	0.52
Climacium dendroides	common tree moss	1.75
Dicranum acutifolium	cushion moss	1.40
Dicranum flagellare	whip fork moss	0.70
Dicranum fragilifolium	cushion moss	0.87
Dicranum fuscescens	curly heron's bill moss	3.67
Dicranum polysetum	electric eels	19.58
Dicranum species		2.97
Dicranum undulatum	wavy dicranum	4.20
Drepanocladus aduncus	common hook moss	0.52
Drepanocladus species		0.17
Eurhynchium pulchellum	common beaked moss	7.52
Helodium blandowii	Blandow's feather moss	0.35
Hylocomium species		0.70
Hylocomium splendens	stair-step moss	52.45
Hypnum cupressiforme	cypress pigtail moss	0.17
Hypnum pallescens	stump pigtail moss	0.17
Jamesoniella autumnalis	Jameson's liverwort	1.40
Lepidozia reptans	little hands liverwort	0.52

Scientific name	Common name	Per cent occurrence
Liverwort		0.35
Marchantia polymorpha	green-tongue liverwort	0.17
Mnium marginatum	edged lantern moss	0.17
Mnium spinulosum	red-mouthed mnium	3.50
Moss		0.87
Oncophorus wahlenbergii	mountain curved-back moss	0.70
Orthotrichum speciosum	showy bristle moss	1.92
Plagiomnium ciliare	toothed mnium	0.17
Plagiomnium cuspidatum	woodsy leafy moss	7.69
Plagiomnium drummondii	Drummond's leafy moss	3.32
Plagiomnium ellipticum	marsh magnificent moss	1.92
Plagiomnium medium	common leafy moss	0.52
Plagiomnium species		0.17
Platygyrium repens		0.70
Pleurozium schreberi	big red stem/Schreber's moss	40.73
Pohlia nutans	copper wire moss	4.37
Polytrichum commune	common hair-cap	16.08
Polytrichum juniperinum	juniper hair-cap	6.99
Polytrichum piliferum	awned hair-cap	2.10
Polytrichum strictum	slender hair-cap	1.75
Ptilidium pulcherrimum	(small wood) naugehyde liverwort	4.55
Ptilium crista-castrensis	knight's plume moss	34.44
Pylaisiella polyantha	stocking (aspen) moss	7.34
Rhizomnium gracile	slender round moss	0.35
Rhytidiadelphus triquetrus	electrified cats-tail moss	0.70
Sanionia uncinata	sickle moss/hook moss	6.29
Sphagnum angustifolium	poor fen peat moss	1.22
Sphagnum capillifolium	acute-leaved peat moss	0.52
Sphagnum fuscum	rusty peat moss	0.87
Sphagnum magellanicum	midway peat moss	0.17
Sphagnum species		0.87
Sphagnum squarrosum	squarrose peat moss	0.70
Sphagnum warnstorfii	Warnstorf's peat moss	0.17
Tetraplodon angustatus	narrow-leaved splachnum	0.17
Thuidium recognitum	hook-leaf fern moss	0.52
Tomentypnum nitens	golden fuzzy fen moss	2.62
Tritomaria exsecta	liverwort	0.35
Warnstorfia fluitans	water hook moss	0.35
Lichen Stratum		
Alectoria sarmentosa	Common witch's hair	0.70
Alectoria species		0.52
Arthonia patellulata	aspen comma	5.77
Bryoria fuscescens	speckled horsehair	0.17

Scientific name	**Common name**	**Per cent occurrence**
Bryoria glabra		5.24
Caloplaca holocarpa		0.87
Cetraria ericetorum	(margined iceland moss)	0.87
Cetraria islandica	iceland moss	0.17
Cetraria pinastri		3.85
Cetraria platyphylla Tuck		4.37
Cladina arbuscula	tree reindeer lichen	0.17
Cladina mitis	green/yellow reindeer lichen	19.41
Cladina portentosa	reindeer lichen	0.17
Cladina rangiferina	grey reindeer lichen	6.64
Cladina stellaris	northern/star reindeer lichen	4.20
Cladina stygia	(black-based) reindeer lichen	0.35
Cladonia amaurocraea	(cup-forming prickle cladonia)	0.70
Cladonia bacilliformis	yellow tiny toothpick cladonia	0.17
Cladonia botrytes	stump cladonia	0.52
Cladonia cariosa	ribbed cladonia/torn club cladonia	0.35
Cladonia cenotea	powdered funnel cladonia	1.75
Cladonia cervicornis	whorled cup lichen	0.87
Cladonia chlorophaea	false pixie-cup	3.85
Cladonia coccifera	British soldier lichen	1.75
Cladonia coniocraea	tiny toothpick cladonia	0.35
Cladonia cornuta	horn cladonia	7.17
Cladonia crispata	shrub funnel cladonia	2.27
Cladonia cristatella	(skinny) British soldiers	1.22
Cladonia deformis	deformed cup	3.32
Cladonia ecmocyna	orange-foot cladonia	4.72
Cladonia fimbriata	(tall false pixie-cup)	6.47
Cladonia furcata	fork lichen	0.70
Cladonia gracilis		6.12
Cladonia gracilis ssp *turbinata*	brown-foot cladonia	2.62
Cladonia macilenta	scarlet toothpick cladonia	0.35
Cladonia multiformis	seive cladonia	2.97
Cladonia phyllophora	black-foot cladonia	0.17
Cladonia pyxidata	brown pixie-cup	1.75
Cladonia species		8.74
Cladonia squamosa		0.70
Cladonia sulphurina	sulphur cup	1.05
Cladonia uncialis	prickle cladonia	1.57
Evernia mesomorpha	spuce moss/northern perfume	7.17
Flavocetraria nivalis	flattened snow lichen	0.35
Hypocenomyce scalaris	common shingle	0.17
Hypogymnia austerodes		0.17
Hypogymnia enteromorpha		0.35

Scientific name	**Common name**	**Per cent occurrence**
Hypogymnia physodes	monk's hood lichen/hooded tube	12.59
Icmadophila ericetorum	fairy puke/spraypaint	0.17
Lecanora impudens		0.17
Melanelia albertana		0.17
Micarea prasina		0.17
Nephroma helveticum	(toothed kidney)	0.17
Nephroma parile	(soridiate kidney)	0.17
Nephroma resupinatum		0.17
Parmelia sulcata	waxpaper lichen/powdered shield	8.92
Parmeliopsis hyperopta	grey starburst	2.27
Peltigera aphthosa	freckle pelt/studded leather lichen	23.60
Peltigera canina	dog pelt/dog lichen	10.14
Peltigera didactyla	temporary pelt/small felt lichen	0.35
Peltigera elisabethae	(lobuled pelt)	0.70
Peltigera horizontalis		1.57
Peltigera kristinssonii		0.17
Peltigera leucophlebia	(veined freckle pelt)	0.52
Peltigera malacea	apple pelt/boxboard felt lichen	1.75
Peltigera neckeri	(shiny powdered pelt)	0.17
Peltigera neopolydactyla	frog pelt/finger felt lichen	1.40
Peltigera polydactyla		4.72
Peltigera rufescens	felt pelt	0.87
Peltigera scabrosa	rough pelt	1.05
Peltigera species		6.82
Stereocaulon tomentosum	woolly coral	0.52
Trapeliopsis granulosa		0.17
Usnea alpina	old man's beard	6.12
Usnea hirta	sugary/shaggy old man's beard	7.52
Usnea lapponica	powdery old man's beard	4.72
Usnea species		1.75
Xanthoria fallax	powdered orange lichen	0.17
Xanthoria species		0.17

denotes species for which fact sheets are available in Appendix F

Table I.3 Species list for ecosite a (47 plots for ecosite a)

Scientific name	Common name	Per cent occurrence
Tree Stratum		
Abies balsamea	balsam fir	2.13
Betula papyrifera	white birch	4.26
Larix laricina	tamarack	4.26
Picea glauca	white spruce	27.66
Picea mariana	black spruce	8.51
Pinus banksiana	jack pine	65.96
Populus tremuloides	aspen	17.02
Shrub Stratum		
Alnus viridis	green alder	14.89
Amelanchier alnifolia	saskatoon	40.43
Apocynum androsaemifolium	spreading dogbane	19.15
Arctostaphylos uva-ursi	common bearberry	91.49
Cornus stolonifera	red-osier dogwood	2.13
Ledum groenlandicum	common Labrador tea	12.77
Linnaea borealis	twinflower	27.66
Lonicera dioica	twining honeysuckle	2.13
Lonicera involucrata	bracted honeysuckle	2.13
Prunus pensylvanica	pin cherry	12.77
Prunus virginiana	choke cherry	4.26
Ribes triste	wild redcurrant	2.13
Rosa acicularis	prickly rose	34.04
Rosa woodsii	common wild rose	4.26
Rubus idaeus	wild red raspberry	4.26
Salix bebbiana	beaked willow	4.26
Salix species		4.26
Shepherdia canadensis	Canada buffaloberry	14.89
Spiraea betulifolia	white meadowsweet	2.13
Vaccinium myrtilloides	common blueberry	82.98
Vaccinium vitis-idaea	bog cranberry	76.60
Forb Stratum		
Achillea millefolium	common yarrow	2.13
Anemone canadensis	Canada anemone	2.13
Anemone multifida	cut-leaved anemone	10.64
Antennaria neglecta	broad-leaved pussytoes	2.13
Antennaria species		8.51
Aralia nudicaulis	wild sarsaparilla	4.26
Artemisia campestris	plains wormwood	4.26
Aster ciliolatus	Lindley's aster	12.77
Aster hesperius	western willow aster	4.26
Aster laevis	smooth aster	4.26
Brachyactis species		2.13
Campanula rotundifolia	harebell	36.17

Scientific name	Common name	Per cent occurrence
Chimaphila umbellata	prince's-pine	2.13
Cornus canadensis	bunchberry	21.28
Cypripedium acaule	stemless lady's-slipper	4.26
Diphasiastrum complanatum	ground-cedar	12.77
Epilobium angustifolium	common fireweed	10.64
Equisetum arvense	common horsetail	4.26
Equisetum hyemale	common scouring-rush	4.26
Equisetum sylvaticum	woodland horsetail	4.26
Fragaria vesca	woodland strawberry	2.13
Fragaria virginiana	wild strawberry	10.64
Galium boreale	northern bedstraw	14.89
Geocaulon lividum	northern bastard toadflax	17.02
Goodyera repens	lesser rattlesnake plantain	4.26
Hieracium umbellatum	narrow-leaved hawkweed	10.64
Lilium philadelphicum	western wood lily	2.13
Lycopodium annotinum	stiff club-moss	4.26
Maianthemum canadense	wild lily-of-the-valley	74.47
Melampyrum lineare	cow-wheat	19.15
Mitella nuda	bishop's-cap	2.13
Moneses uniflora	one-flowered wintergreen	2.13
Orthilia secunda	one-sided wintergreen	6.38
Pedicularis labradorica	Labrador lousewort	4.26
Phacelia franklinii	Franklin's scorpionweed	2.13
Potentilla tridentata	three-toothed cinquefoil	8.51
Pyrola asarifolia	common pink wintergreen	8.51
Pyrola chlorantha	greenish-flowered wintergreen	12.77
Pyrola chlorantha	greenish-flowered wintergreen	2.13
Saxifraga tricuspidata	three-toothed saxifrage	2.13
Selaginella selaginoides	spiny-edged little club-moss	2.13
Solidago multiradiata	alpine goldenrod	2.13
Solidago nemoralis	showy goldenrod	6.38
Solidago simplex		12.77
Solidago species		2.13
Trientalis borealis	northern starflower	6.38
Viola adunca	early blue violet	4.26
Viola nephrophylla	bog violet	2.13
Viola renifolia	kidney-leaved violet	4.26
Grass Stratum		
Calamagrostis canadensis	bluejoint	23.40
Carex gynocrates	northern bog sedge	4.26
Carex leptalea	bristle-stalked sedge	2.13
Carex siccata	hay sedge	2.13
Carex species		6.38

Scientific name	Common name	Per cent occurrence
Carex vaginata	sheathed sedge	2.13
Elymus glaucus	smooth wildrye	4.26
Elymus trachycaulus	slender wheatgrass	2.13
Juncus balticus	wire rush	2.13
Leymus innovatus	hairy wildrye	38.30
Oryzopsis pungens	northern rice grass	34.04
Moss Stratum		
Ceratodon purpureus	purple horn-toothed moss	2.13
Dicranum acutifolium	cushion moss	2.13
Dicranum fuscescens	curly heron's bill moss	2.13
Dicranum polysetum	electric eels	42.55
Dicranum species		10.64
Dicranum undulatum	wavy dicranum	2.13
Hylocomium splendens	stair-step moss	10.64
Plagiomnium cuspidatum	woodsy leafy moss	2.13
Pleurozium schreberi	big red stem/Schreber's moss	40.43
Pohlia nutans	copper wire moss	10.64
Polytrichum commune	common hair-cap	19.15
Polytrichum juniperinum	juniper hair-cap	23.40
Polytrichum piliferum	awned hair-cap	14.89
Polytrichum strictum	slender hair-cap	2.13
Ptilium crista-castrensis	knight's plume moss	12.77
Ptilidium pulcherrimum	(small wood) naugehyde liverwort	4.26
Sanionia uncinata	sickle moss/hook moss	2.13
Tetraplodon angustatus	narrow-leaved splachnum	2.13
Tomentypnum nitens	golden fuzzy fen moss	2.13
Warnstorfia fluitans	water hook moss	2.13
Lichen Stratum		
Arthonia patellulata	aspen comma	2.13
Bryoria glabra		10.64
Cetraria ericetorum	(margined iceland moss)	6.38
Cetraria islandica	iceland moss	2.13
Cetraria pinastri		10.64
Cetraria platyphylla Tuck		10.64
Cladonia amaurocraea	(cup-forming prickle cladonia)	6.38
Cladina arbuscula	tree reindeer lichen	2.13
Cladonia cariosa	ribbed cladonia/torn club cladonia	2.13
Cladonia cenotea	powdered funnel cladonia	6.38
Cladonia cervicornis	whorled cup lichen	4.26
Cladonia cervicornis	whorled cup lichen	2.13
Cladonia chlorophaea	false pixie-cup	6.38
Cladonia coccifera	British soldier lichen	17.02

Scientific name	Common name	Per cent occurrence
Cladonia cornuta	horn cladonia	19.15
Cladonia crispata	shrub funnel cladonia	12.77
Cladonia cristatella	(skinny) British soldiers	2.13
Cladonia deformis	deformed cup	14.89
Cladonia ecmocyna	orange-foot cladonia	17.02
Cladonia fimbriata	(tall false pixie-cup)	8.51
Cladonia gracilis		31.91
Cladina mitis	green/yellow reindeer lichen	68.09
Cladonia multiformis	seive cladonia	2.13
Cladonia pyxidata	brown pixie-cup	4.26
Cladina rangiferina	grey reindeer lichen	31.91
Cladonia species		29.79
Cladina stellaris	northern/star reindeer lichen	25.53
Cladonia uncialis	prickle cladonia	14.89
Evernia mesomorpha	spuce moss/northern perfume	19.15
Flavocetraria nivalis	flattened snow lichen	2.13
Hypogymnia physodes	monk's hood lichen/hooded tube	29.79
Parmeliopsis hyperopta	grey starburst	14.89
Parmelia sulcata	waxpaper lichen/powdered shield	17.02
Peltigera aphthosa	freckle pelt/studded leather lichen	31.91
Peltigera canina	dog pelt/dog lichen	8.51
Peltigera malacea	apple pelt/boxboard felt lichen	2.13
Peltigera polydactyla		4.26
Peltigera species		19.15
Stereocaulon tomentosum	woolly coral	6.38
Usnea alpina	old man's beard	8.51
Usnea hirta	sugary/shaggy old man's beard	27.66
Usnea lapponica	powdery old man's beard	10.64
Usnea species		6.38

denotes species for which fact sheets are available in Appendix F

Table I.4 Species list for ecosite b (66 plots for ecosite b)

Scientific name	Common name	Per cent occurrence
Tree Stratum		
Abies balsamea	balsam fir	1.52
Betula papyrifera	white birch	36.36
Picea glauca	white spruce	36.36
Picea mariana	black spruce	22.73
Pinus banksiana	jack pine	62.12
Populus balsamifera	balsam poplar	3.03
Populus tremuloides	aspen	96.97
Shrub Stratum		
Actaea rubra	red and white baneberry	1.52
Alnus incana ssp *tenuifolia*	river alder	3.03
Alnus viridis	green alder	51.52
Amelanchier alnifolia	saskatoon	31.82
Apocynum androsaemifolium	spreading dogbane	3.03
Arctostaphylos uva-ursi	common bearberry	53.03
Empetrum nigrum	crowberry	1.52
Juniperus communis	ground juniper	1.52
Ledum groenlandicum	common Labrador tea	46.97
Linnaea borealis	twinflower	75.76
Lonicera dioica	twining honeysuckle	6.06
Lonicera involucrata	bracted honeysuckle	7.58
Prunus pensylvanica	pin cherry	22.73
Prunus virginiana	choke cherry	9.09
Ribes triste	wild redcurrant	4.55
Rosa acicularis	prickly rose	60.61
Rosa woodsii	common wild rose	16.67
Rubus idaeus	wild red raspberry	12.12
Rubus pubescens	dewberry	21.21
Salix bebbiana	beaked willow	18.18
Salix species		27.27
Shepherdia canadensis	Canada buffaloberry	22.73
Symphoricarpos albus	snowberry	7.58
Symphoricarpos occidentalis	buckbrush	1.52
Vaccinium myrtilloides	common blueberry	90.91
Vaccinium vitis-idaea	bog cranberry	78.79
Viburnum edule	low-bush cranberry	34.85
Forb Stratum		
Achillea millefolium	common yarrow	18.18
Anemone multifida	cut-leaved anemone	7.58
Antennaria species		3.03
Aralia nudicaulis	wild sarsaparilla	43.94
Artemisia campestris	plains wormwood	1.52
Aster ciliolatus	Lindley's aster	19.70

Scientific name	**Common name**	**Per cent occurrence**
Aster conspicuus	showy aster	3.03
Aster species		1.52
Brachyactis species		4.55
Campanula rotundifolia	harebell	16.67
Capsella bursa-pastoris	shepherd's-purse	4.55
Castilleja miniata	common redpaintbrush	1.52
Cirsium hookerianum	white thistle	1.52
Coptis trifolia	goldthread	1.52
Corallorhiza maculata	spotted coralroot	1.52
Cornus canadensis	bunchberry	78.79
Corydalis sempervirens	pink corydalis	1.52
Diphasiastrum complanatum	ground-cedar	30.30
Epilobium angustifolium	common fireweed	78.79
Equisetum arvense	common horsetail	12.12
Equisetum pratense	meadow horsetail	7.58
Equisetum scirpoides	dwarf scouring-rush	1.52
Equisetum sylvaticum	woodland horsetail	18.18
Erysimum cheiranthoides	wormseed mustard	3.03
Fragaria virginiana	wild strawberry	31.82
Galium boreale	northern bedstraw	34.85
Galium triflorum	sweet-scented bedstraw	1.52
Geocaulon lividum	northern bastard toadflax	22.73
Goodyera repens	lesser rattlesnake plantain	7.58
Hieracium umbellatum	narrow-leaved hawkweed	7.58
Lathyrus ochroleucus	cream-colored vetchling	34.85
Lathyrus venosus	purple peavine	3.03
Lilium philadelphicum	western wood lily	6.06
Lycopodium annotinum	stiff club-moss	12.12
Lycopodium clavatum	running club-moss	3.03
Lycopodium obscurum	ground-pine	15.15
Maianthemum canadense	wild lily-of-the-valley	72.73
Melampyrum lineare	cow-wheat	19.70
Mertensia paniculata	tall lungwort	4.55
Microseris nutans	nodding scorzonella	1.52
Mitella nuda	bishop's-cap	10.61
Monotropa uniflora	Indian-pipe	3.03
Orthilia secunda	one-sided wintergreen	25.76
Pedicularis labradorica	Labrador lousewort	9.09
Petasites frigidus var palmatus	palmate-leaved coltsfoot	25.76
Potentilla tridentata	three-toothed cinquefoil	7.58
Pyrola asarifolia	common pink wintergreen	18.18
Pyrola chlorantha	greenish-flowered wintergreen	1.52
Saxifraga tricuspidata	three-toothed saxifrage	1.52
Smilacina racemosa		1.52

Scientific name	**Common name**	**Per cent occurrence**
Solidago canadensis	Canada goldenrod	1.52
Solidago nemoralis	showy goldenrod	1.52
Solidago simplex		1.52
Sonchus arvensis	perennial sow-thistle	3.03
Streptopus amplexifolius	clasping-leaved twisted-stalk	1.52
Taraxacum officinale	common dandelion	3.03
Thalictrum venulosum	veiny meadowrue	1.52
Trientalis borealis	northern starflower	36.36
Trifolium hybridum	alsike clover	3.03
Vicia americana	wild vetch	13.64
Viola adunca	early blue violet	4.55
Viola canadensis	western Canada violet	3.03
Viola nuttallii	yellow prairie violet	1.52
Viola renifolia	kidney-leaved violet	6.06
Grass Stratum		
Calamagrostis canadensis	bluejoint	45.45
Carex siccata	hay sedge	1.52
Carex species		9.09
Elymus glaucus	smooth wildrye	10.61
Hierochloe hirta ssp arctica	sweetgrass	1.52
Leymus innovatus	hairy wildrye	66.67
Oryzopsis asperifolia	white-grained mountain rice grass	4.55
Oryzopsis canadensis	Canadian rice grass	1.52
Oryzopsis pungens	northern rice grass	1.52
Poa pratensis	Kentucky bluegrass	1.52
Schizachne purpurascens	purple oatgrass	1.52
Moss Stratum		
Aulacomnium palustre	tufted moss/glow moss	3.03
Brachythecium hylotapetum	woodsy ragged moss	1.52
Bryum pseudotriquetrum	tall clustered thread moss	1.52
Ceratodon purpureus	purple horn-toothed moss	1.52
Dicranum acutifolium	cushion moss	3.03
Dicranum flagellare	whip fork moss	1.52
Dicranum polysetum	electric eels	15.15
Dicranum species		9.09
Eurhynchium pulchellum	common beaked moss	1.52
Hylocomium splendens	stair-step moss	42.42
Orthotrichum speciosum	showy bristle moss	10.61
Plagiomnium cuspidatum	woodsy leafy moss	3.03
Pleurozium schreberi	big red stem/Schreber's moss	43.94
Polytrichum commune	common hair-cap	48.48
Polytrichum juniperinum	juniper hair-cap	1.52
Polytrichum piliferum	awned hair-cap	1.52
Ptilidium pulcherrimum	(small wood) naugehyde liverwort	1.52

Scientific name	**Common name**	**Per cent occurrence**
Ptilium crista-castrensis	knight's plume moss	22.73
Pylaisiella polyantha	stocking (aspen) moss	4.55
Sanionia uncinata	sickle moss/hook moss	1.52
Tomentypnum nitens	golden fuzzy fen moss	3.03
Lichen Stratum		
Alectoria sarmentosa	Common witch's hair	1.52
Arthonia patellulata	aspen comma	12.12
Bryoria glabra		6.06
Caloplaca holocarpa		4.55
Cetraria pinastri		4.55
Cetraria platyphylla Tuck		7.58
Cladina mitis	green/yellow reindeer lichen	16.67
Cladina rangiferina	grey reindeer lichen	1.52
Cladina stellaris	northern/star reindeer lichen	1.52
Cladonia crispata	shrub funnel cladonia	1.52
Cladonia ecmocyna	orange-foot cladonia	3.03
Cladonia fimbriata	(tall false pixie-cup)	1.52
Cladonia furcata	fork lichen	1.52
Cladonia gracilis		6.06
Cladonia multiformis	seive cladonia	1.52
Cladonia species		27.27
Cladonia squamosa		4.55
Evernia mesomorpha	spuce moss/northern perfume	4.55
Hypogymnia physodes	monk's hood lichen/hooded tube	16.67
Melanelia albertana		1.52
Parmelia sulcata	waxpaper lichen/powdered shield	9.09
Parmeliopsis hyperopta	grey starburst	1.52
Peltigera aphthosa	freckle pelt/studded leather lichen	13.64
Peltigera canina	dog pelt/dog lichen	1.52
Peltigera polydactyla		1.52
Peltigera species		19.70
Usnea alpina	old man's beard	9.09
Usnea hirta	sugary/shaggy old man's beard	3.03
Usnea lapponica	powdery old man's beard	1.52

denotes species for which fact sheets are available in Appendix F

Table I.5 Species list for ecosite c (25 plots for ecosite c)

Scientific name	Common name	Per cent occurrence
Tree Stratum		
Abies balsamea	balsam fir	4.00
Betula glandulosa	bog birch	4.00
Betula papyrifera	white birch	32.00
Betula pumila	dwarf birch	4.00
Picea glauca	white spruce	16.00
Picea mariana	black spruce	40.00
Pinus banksiana	jack pine	52.00
Populus balsamifera	balsam poplar	4.00
Populus tremuloides	aspen	32.00
Shrub Stratum		
Alnus incana ssp *tenuifolia*	river alder	4.00
Alnus viridis	green alder	36.00
Amelanchier alnifolia	saskatoon	8.00
Arctostaphylos uva-ursi	common bearberry	32.00
Ledum groenlandicum	common Labrador tea	76.00
Linnaea borealis	twinflower	68.00
Prunus pensylvanica	pin cherry	8.00
Rosa acicularis	prickly rose	36.00
Rosa woodsii	common wild rose	12.00
Rubus idaeus	wild red raspberry	8.00
Rubus pubescens	dewberry	12.00
Salix bebbiana	beaked willow	32.00
Salix drummondiana	Drummond's willow	4.00
Salix species		8.00
Shepherdia canadensis	Canada buffaloberry	12.00
Vaccinium myrtilloides	common blueberry	88.00
Vaccinium vitis-idaea	bog cranberry	76.00
Viburnum edule	low-bush cranberry	8.00
Forb Stratum		
Achillea millefolium	common yarrow	4.00
Aralia nudicaulis	wild sarsaparilla	12.00
Aster species		4.00
Campanula rotundifolia	harebell	16.00
Cornus canadensis	bunchberry	84.00
Diphasiastrum complanatum	ground-cedar	12.00
Epilobium angustifolium	common fireweed	36.00
Equisetum arvense	common horsetail	8.00
Equisetum pratense	meadow horsetail	8.00
Equisetum scirpoides	dwarf scouring-rush	4.00
Equisetum sylvaticum	woodland horsetail	28.00
Fragaria virginiana	wild strawberry	16.00
Galium boreale	northern bedstraw	16.00

Scientific name	**Common name**	**Per cent occurrence**
Geocaulon lividum	northern bastard toadflax	24.00
Goodyera repens	lesser rattlesnake plantain	24.00
Lathyrus ochroleucus	cream-colored vetchling	12.00
Lilium philadelphicum	western wood lily	4.00
Lycopodium annotinum	stiff club-moss	24.00
Lycopodium clavatum	running club-moss	8.00
Maianthemum canadense	wild lily-of-the-valley	40.00
Melampyrum lineare	cow-wheat	8.00
Orthilia secunda	one-sided wintergreen	20.00
Petasites frigidus var palmatus	palmate-leaved coltsfoot	20.00
Pyrola chlorantha	greenish-flowered wintergreen	12.00
Saxifraga tricuspidata	three-toothed saxifrage	4.00
Trientalis borealis	northern starflower	40.00
Viola renifolia	kidney-leaved violet	8.00
Grass Stratum		
Calamagrostis canadensis	bluejoint	12.00
Calamagrostis species		4.00
Calamagrostis stricta	narrow reedgrass	4.00
Carex siccata	hay sedge	4.00
Festuca ovina	sheep fescue	4.00
Leymus innovatus	hairy wildrye	40.00
Oryzopsis canadensis	Canadian rice grass	4.00
Oryzopsis pungens	northern rice grass	20.00
Moss Stratum		
Aulacomnium palustre	tufted moss/glow moss	4.00
Calliergon cordifolium	heart-leaved feather moss	4.00
Calliergon giganteum	giant water moss	4.00
Dicranum fuscescens	curly heron's bill moss	8.00
Dicranum polysetum	electric eels	68.00
Hylocomium splendens	stair-step moss	60.00
Lepidozia reptans	little hands liverwort	4.00
Plagiomnium ellipticum	marsh magnificent moss	4.00
Pleurozium schreberi	big red stem/Schreber's moss	48.00
Pohlia nutans	copper wire moss	8.00
Polytrichum commune	common hair-cap	24.00
Polytrichum juniperinum	juniper hair-cap	16.00
Ptilidium pulcherrimum	(small wood) naugehyde liverwort	8.00
Ptilium crista-castrensis	knight's plume moss	52.00
Sphagnum angustifolium	poor fen peat moss	4.00
Sphagnum magellanicum	midway peat moss	4.00
Warnstorfia fluitans	water hook moss	4.00

Scientific name	Common name	Per cent occurrence
Lichen Stratum		
Alectoria species		4.00
Arthonia patellulata	aspen comma	16.00
Bryoria glabra		28.00
Cetraria ericetorum	(margined iceland moss)	8.00
Cetraria pinastri		28.00
Cetraria platyphylla Tuck		20.00
Cladina mitis	green/yellow reindeer lichen	60.00
Cladina rangiferina	grey reindeer lichen	16.00
Cladina stellaris	northern/star reindeer lichen	12.00
Cladonia cenotea	powdered funnel cladonia	8.00
Cladonia chlorophaea	false pixie-cup	4.00
Cladonia cornuta	horn cladonia	16.00
Cladonia crispata	shrub funnel cladonia	8.00
Cladonia deformis	deformed cup	8.00
Cladonia ecmocyna	orange-foot cladonia	8.00
Cladonia fimbriata	(tall false pixie-cup)	12.00
Cladonia furcata	fork lichen	4.00
Cladonia gracilis		20.00
Cladonia macilenta	scarlet toothpick cladonia	4.00
Cladonia multiformis	seive cladonia	8.00
Cladonia pyxidata	brown pixie-cup	4.00
Cladonia species		8.00
Evernia mesomorpha	spuce moss/northern perfume	20.00
Hypogymnia enteromorpha		4.00
Hypogymnia physodes	monk's hood lichen/hooded tube	36.00
Parmelia sulcata	waxpaper lichen/powdered shield	20.00
Parmeliopsis hyperopta	grey starburst	12.00
Peltigera aphthosa	freckle pelt/studded leather lichen	52.00
Peltigera canina	dog pelt/dog lichen	16.00
Peltigera malacea	apple pelt/boxboard felt lichen	8.00
Peltigera polydactyla		4.00
Peltigera species		4.00
Usnea alpina	old man's beard	20.00
Usnea hirta	sugary/shaggy old man's beard	24.00
Usnea lapponica	powdery old man's beard	16.00
Usnea species		4.00

denotes species for which fact sheets are available in Appendix F

Table I.6 Species list for ecosite d (248 plots for ecosite d)

Scientific name	Common name	Per cent occurrence
Tree Stratum		
Abies balsamea	balsam fir	27.82
Betula glandulosa	bog birch	0.40
Betula papyrifera	white birch	39.11
Larix laricina	tamarack	0.81
Picea glauca	white spruce	81.05
Picea mariana	black spruce	3.23
Pinus banksiana	jack pine	3.63
Pinus contorta	lodgepole pine	0.40
Populus balsamifera	balsam poplar	27.42
Populus tremuloides	aspen	85.89
Shrub Stratum		
Actaea rubra	red and white baneberry	21.77
Alnus incana ssp *tenuifolia*	river alder	6.45
Alnus species		0.40
Alnus viridis	green alder	30.24
Amelanchier alnifolia	saskatoon	32.66
Apocynum androsaemifolium	spreading dogbane	1.61
Arctostaphylos uva-ursi	common bearberry	6.05
Cornus stolonifera	red-osier dogwood	16.94
Corylus cornuta	beaked hazelnut	10.89
Ledum glandulosum	glandular Labrador tea	0.40
Ledum groenlandicum	common Labrador tea	20.16
Linnaea borealis	twinflower	75.40
Lonicera dioica	twining honeysuckle	27.82
Lonicera involucrata	bracted honeysuckle	19.35
Oxycoccus microcarpus	small bog cranberry	0.81
Potentilla fruticosa	shrubby cinquefoil	0.40
Prunus pensylvanica	pin cherry	4.84
Prunus virginiana	choke cherry	2.82
Rhamnus alnifolia	alder-leaved buckthorn	0.40
Ribes glandulosum	skunk currant	3.63
Ribes hudsonianum	northern blackcurrant	2.02
Ribes lacustre	bristly black currant	12.90
Ribes laxiflorum	mountain currant	0.40
Ribes oxyacanthoides	northern gooseberry	17.34
Ribes triste	wild redcurrant	34.27
Rosa acicularis	prickly rose	85.48
Rosa woodsii	common wild rose	10.08
Rubus arcticus	dwarf raspberry	0.40
Rubus idaeus	wild red raspberry	35.08

Scientific name	Common name	Per cent occurrence
Rubus pedatus	dwarf bramble	0.81
Rubus pubescens	dewberry	75.40
Salix athabascensis	Athabasca willow	0.40
Salix bebbiana	beaked willow	16.13
Salix discolor	pussy willow	0.81
Salix myrtillifolia	myrtle-leaved willow	0.40
Salix scouleriana	Scouler's willow	0.81
Salix species		31.45
Shepherdia canadensis	Canada buffaloberry	26.21
Sorbus scopulina	western mountain-ash	0.40
Spiraea betulifolia	white meadowsweet	0.40
Symphoricarpos albus	snowberry	19.76
Symphoricarpos occidentalis	buckbrush	2.82
Symphoricarpos species		0.40
Vaccinium caespitosum	dwarf bilberry	1.61
Vaccinium membranaceum	tall bilberry	0.40
Vaccinium myrtilloides	common blueberry	24.19
Vaccinium myrtillus	low bilberry	0.81
Vaccinium scoparium	grouseberry	0.40
Vaccinium vitis-idaea	bog cranberry	22.98
Viburnum edule	low-bush cranberry	89.11
Viburnum opulus	high-bush cranberry	0.40
Forb Stratum		
Achillea millefolium	common yarrow	22.58
Achillea sibirica	many-flowered yarrow	0.40
Agastache foeniculum	giant hyssop	0.40
Anemone canadensis	Canada anemone	0.40
Antennaria species		0.40
Aralia nudicaulis	wild sarsaparilla	56.85
Arnica cordifolia	heart-leaved arnica	1.21
Aster ciliolatus	Lindley's aster	35.48
Aster conspicuus	showy aster	18.15
Aster species		2.42
Athyrium filix-femina	lady fern	0.81
Brachyactis species		17.74
Campanula rotundifolia	harebell	2.02
Capsella bursa-pastoris	shepherd's-purse	0.40
Castilleja miniata	common redpaintbrush	0.40
Cirsium arvense	creeping thistle	0.40
Coptis trifolia	goldthread	2.42
Corallorhiza maculata	spotted coralroot	1.61

Scientific name	Common name	Per cent occurrence
Corallorhiza striata	striped coralroot	0.40
Corallorhiza trifida	pale coralroot	1.21
Cornus canadensis	bunchberry	86.29
Cypripedium acaule	stemless lady's-slipper	0.40
Delphinium glaucum	tall larkspur	1.61
Diphasiastrum complanatum	ground-cedar	3.23
Disporum trachycarpum	fairybells	11.69
Dryopteris carthusiana	narrow spinulose shield fern	1.61
Epilobium angustifolium	common fireweed	70.56
Equisetum arvense	common horsetail	19.76
Equisetum palustre	marsh horsetail	0.81
Equisetum pratense	meadow horsetail	8.06
Equisetum scirpoides	dwarf scouring-rush	2.02
Equisetum species		1.81
Equisetum sylvaticum	woodland horsetail	22.18
Fragaria vesca	woodland strawberry	4.84
Fragaria virginiana	wild strawberry	59.27
Galeopsis tetrahit	hemp-nettle	0.40
Galium boreale	northern bedstraw	48.79
Galium species		0.40
Galium triflorum	sweet-scented bedstraw	19.76
Geocaulon lividum	northern bastard toadflax	8.87
Geranium species		0.40
Goodyera repens	lesser rattlesnake plantain	14.92
Gymnocarpium dryopteris	oak fern	0.40
Haplopappus species		1.21
Hedysarum alpinum	alpine hedysarum	0.40
Hedysarum boreale	northern hedysarum	0.81
Heracleum lanatum	cow parsnip	0.40
Hieracium umbellatum	narrow-leaved hawkweed	2.42
Lathyrus ochroleucus	cream-colored vetchling	50.81
Lathyrus venosus	purple peavine	1.21
Lilium philadelphicum	western wood lily	1.61
Lycopodium annotinum	stiff club-moss	19.76
Lycopodium clavatum	running club-moss	2.02
Lycopodium obscurum	ground-pine	6.45
Maianthemum canadense	wild lily-of-the-valley	64.92
Malaxis monophylla	white adder's-mouth	0.40
Matteuccia struthiopteris	ostrich fern	0.40
Melampyrum lineare	cow-wheat	0.81
Mentha arvensis	wild mint	0.40

Scientific name	Common name	Per cent occurrence
Mertensia paniculata	tall lungwort	66.94
Minuartia species		0.40
Mitella nuda	bishop's-cap	46.37
Moehringia lateriflora	blunt-leaved sandwort	0.40
Moneses uniflora	one-flowered wintergreen	0.40
Monotropa uniflora	Indian-pipe	0.40
Orthilia secunda	one-sided wintergreen	35.89
Pedicularis labradorica	Labrador lousewort	0.81
Petasites frigidus var palmatus	palmate-leaved coltsfoot	67.34
Platanthera obtusata	blunt-leaved bog orchid	0.81
Platanthera orbiculata	round-leaved bog orchid	3.63
Polygonum species		1.21
Pyrola asarifolia	common pink wintergreen	45.97
Pyrola chlorantha	greenish-flowered wintergreen	12.90
Pyrola elliptica	white wintergreen	0.40
Pyrola species		1.21
Sanicula marilandica	snakeroot	0.40
Smilacina stellata	star-flowered Solomon's-seal	1.21
Solidago canadensis	Canada goldenrod	0.40
Solidago nemoralis	showy goldenrod	3.63
Solidago simplex		1.21
Solidago species		1.21
Sonchus arvensis	perennial sow-thistle	0.40
Spiranthes romanzoffiana	hooded ladies'-tresses	1.21
Stellaria longifolia	long-leaved chickweed	0.40
Streptopus amplexifolius	clasping-leaved twisted-stalk	0.81
Taraxacum officinale	common dandelion	5.65
Thalictrum occidentale	western meadowrue	0.40
Thalictrum species		0.40
Thalictrum venulosum	veiny meadowrue	3.63
Thlaspi arvense	stinkweed	0.40
Trientalis borealis	northern starflower	39.11
Trientalis europaea	arctic starflower	0.81
Trifolium hybridum	alsike clover	0.40
Trifolium pratense	red clover	1.21
Urtica dioica	common nettle	0.40
Vicia americana	wild vetch	32.26
Viola adunca	early blue violet	2.42
Viola canadensis	western Canada violet	8.87
Viola orbiculata	evergreen violet	0.40
Viola renifolia	kidney-leaved violet	35.89
Viola species		0.81

Scientific name	Common name	Per cent occurrence
Grass Stratum		
Agropyron species		0.40
Agrostis scabra	rough hairgrass	0.40
Bromus ciliatus	fringed brome	1.21
Bromus vulgaris	woodland brome	0.40
Calamagrostis canadensis	bluejoint	66.94
Calamagrostis inexpansa	northern reedgrass	1.61
Calamagrostis species		0.81
Carex concinna	beautiful sedge	0.40
Carex deflexa	bent sedge	0.40
Carex disperma	two-seeded sedge	0.40
Carex peckii	Peck's sedge	0.40
Carex rossii	Ross' sedge	1.21
Carex siccata	hay sedge	1.21
Carex species		6.85
Carex vaginata	sheathed sedge	1.21
Elymus species		0.40
Elymus trachycaulus	slender wheatgrass	0.81
Festuca species		0.40
Leymus innovatus	hairy wildrye	36.69
Oryzopsis asperifolia	white-grained mountain rice grass	6.85
Oryzopsis canadensis	Canadian rice grass	0.81
Oryzopsis pungens	northern rice grass	1.21
Poa palustris	fowl bluegrass	0.40
Schizachne purpurascens	purple oatgrass	4.84
Moss Stratum		
Amblystegium serpens		0.40
Aulacomnium palustre	tufted moss/glow moss	2.42
Barbilophozia barbata	liverwort	0.40
Brachythecium campestre		1.21
Brachythecium collinum		0.40
Brachythecium salebrosum	golden ragged moss	1.61
Campylium hispidulum		2.02
Ceratodon purpureus	purple horn-toothed moss	2.42
Cinclidium stygium	common northen lantern moss	0.40
Climacium dendroides	common tree moss	1.21
Dicranum acutifolium	cushion moss	1.21
Dicranum flagellare	whip fork moss	0.81
Dicranum fragilifolium	cushion moss	0.81
Dicranum fuscescens	curly heron's bill moss	4.03
Dicranum polysetum	electric eels	19.76
Dicranum species		0.81
Dicranum undulatum	wavy dicranum	0.81

Scientific name	**Common name**	**Per cent occurrence**
Drepanocladus aduncus	common hook moss	0.81
Eurhynchium pulchellum	common beaked moss	12.90
Hylocomium splendens	stair-step moss	53.63
Hypnum pallescens	stump pigtail moss	0.40
Jamesoniella autumnalis	Jameson's liverwort	2.82
Lepidozia reptans	little hands liverwort	0.40
Mnium marginatum	edged lantern moss	0.40
Mnium spinulosum	red-mouthed mnium	6.85
Moss		0.40
Oncophorus wahlenbergii	mountain curved-back moss	1.61
Orthotrichum speciosum	showy bristle moss	1.61
Parmeliopsis hyperopta	grey starburst	0.40
Plagiomnium cuspidatum	woodsy leafy moss	12.50
Plagiomnium drummondii	Drummond's leafy moss	6.05
Plagiomnium medium	common leafy moss	0.40
Platygyrium repens		1.21
Pleurozium schreberi	big red stem/Schreber's moss	41.53
Pohlia nutans	copper wire moss	4.84
Polytrichum commune	common hair-cap	12.10
Polytrichum juniperinum	juniper hair-cap	3.63
Polytrichum piliferum	awned hair-cap	0.40
Polytrichum strictum	slender hair-cap	0.81
Ptilidium pulcherrimum	(small wood) naugehyde liverwort	5.65
Ptilium crista-castrensis	knight's plume moss	34.27
Pylaisiella polyantha	stocking (aspen) moss	10.48
Rhizomnium gracile	slender round moss	0.40
Rhytidiadelphus triquetrus	electrified cats-tail moss	1.21
Sanionia uncinata	sickle moss/hook moss	10.89
Sphagnum squarrosum	squarrose peat moss	0.40
Thuidium recognitum	hook-leaf fern moss	0.81
Tritomaria exsecta	liverwort	0.81
Lichen Stratum		
Alectoria sarmentosa	Common witch's hair	0.81
Alectoria species		0.81
Arthonia patellulata	aspen comma	7.66
Bryoria glabra		3.23
Caloplaca holocarpa		0.81
Cetraria pinastri		2.02
Cetraria platyphylla Tuck		3.23
Cladina mitis	green/yellow reindeer lichen	6.45
Cladina rangiferina	grey reindeer lichen	1.21
Cladina stellaris	northern/star reindeer lichen	0.81
Cladonia botrytes	stump cladonia	0.40

Scientific name	Common name	Per cent occurrence
Cladonia cenotea	powdered funnel cladonia	1.61
Cladonia cervicornis	whorled cup lichen	0.81
Cladonia chlorophaea	false pixie-cup	5.24
Cladonia coccifera	British soldier lichen	0.40
Cladonia coniocraea	tiny toothpick cladonia	0.40
Cladonia cornuta	horn cladonia	6.05
Cladonia crispata	shrub funnel cladonia	0.81
Cladonia cristatella	(skinny) British soldiers	0.40
Cladonia deformis	deformed cup	0.40
Cladonia ecmocyna	orange-foot cladonia	5.24
Cladonia fimbriata	(tall false pixie-cup)	8.87
Cladonia furcata	fork lichen	0.81
Cladonia gracilis		3.23
Cladonia multiformis	seive cladonia	3.63
Cladonia pyxidata	brown pixie-cup	2.82
Cladonia species		4.84
Cladonia squamosa		0.40
Evernia mesomorpha	spuce moss/northern perfume	6.05
Hypogymnia physodes	monk's hood lichen/hooded tube	10.48
Nephroma helveticum	(toothed kidney)	0.40
Nephroma parile	(soridiate kidney)	0.40
Parmelia sulcata	waxpaper lichen/powdered shield	8.87
Peltigera aphthosa	freckle pelt/studded leather lichen	21.37
Peltigera canina	dog pelt/dog lichen	16.94
Peltigera elisabethae	(lobuled pelt)	0.81
Peltigera horizontalis		3.23
Peltigera malacea	apple pelt/boxboard felt lichen	2.02
Peltigera polydactyla		8.06
Peltigera rufescens	felt pelt	1.21
Peltigera scabrosa	rough pelt	1.61
Peltigera species		5.65
Usnea alpina	old man's beard	5.24
Usnea hirta	sugary/shaggy old man's beard	6.05
Usnea lapponica	powdery old man's beard	4.03
Usnea species		2.02
Xanthoria fallax	powdered orange lichen	0.40
Xanthoria species		0.40

denotes species for which fact sheets are available in Appendix F

Table I.7 Species list for ecosite e (58 plots for ecosite e)

Scientific name	Common name	Per cent occurrence
Tree Stratum		
Abies balsamea	balsam fir	25.86
Betula glandulosa	bog birch	1.72
Betula papyrifera	white birch	62.07
Larix laricina	tamarack	1.72
Picea glauca	white spruce	63.79
Picea mariana	black spruce	5.17
Pinus banksiana	jack pine	3.45
Pinus contorta	lodgepole pine	1.72
Populus balsamifera	balsam poplar	55.17
Populus tremuloides	aspen	74.14
Shrub Stratum		
Actaea rubra	red and white baneberry	25.86
Alnus incana ssp tenuifolia	river alder	8.62
Alnus viridis	green alder	36.21
Amelanchier alnifolia	saskatoon	37.93
Arctostaphylos uva-ursi	common bearberry	6.90
Berberis repens	creeping mahonia	1.72
Cornus stolonifera	red-osier dogwood	34.48
Corylus cornuta	beaked hazelnut	10.34
Ledum groenlandicum	common Labrador tea	22.41
Linnaea borealis	twinflower	56.90
Lonicera dioica	twining honeysuckle	22.41
Lonicera involucrata	bracted honeysuckle	50.00
Oxycoccus microcarpus	small bog cranberry	1.72
Prunus virginiana	choke cherry	3.45
Rhamnus alnifolia	alder-leaved buckthorn	3.45
Ribes glandulosum	skunk currant	10.34
Ribes hirtellum	wild gooseberry	1.72
Ribes hudsonianum	northern blackcurrant	10.34
Ribes lacustre	bristly black currant	27.59
Ribes laxiflorum	mountain currant	3.45
Ribes oxyacanthoides	northern gooseberry	60.34
Ribes species		1.72
Ribes triste	wild redcurrant	46.55
Rosa acicularis	prickly rose	84.48
Rosa woodsii	common wild rose	8.62
Rubus idaeus	wild red raspberry	62.07
Rubus parviflorus	thimbleberry	3.45
Rubus pedatus	dwarf bramble	3.45
Rubus pubescens	dewberry	67.24
Salix bebbiana	beaked willow	20.69

Scientific name	Common name	Per cent occurrence
Salix discolor	pussy willow	3.45
Salix glauca	smooth willow	1.72
Salix scouleriana	Scouler's willow	3.45
Salix species		43.10
Shepherdia canadensis	Canada buffaloberry	32.76
Spiraea betulifolia	white meadowsweet	1.72
Symphoricarpos albus	snowberry	24.14
Vaccinium caespitosum	dwarf bilberry	3.45
Vaccinium membranaceum	tall bilberry	1.72
Vaccinium myrtilloides	common blueberry	8.62
Vaccinium myrtillus	low bilberry	1.72
Vaccinium vitis-idaea	bog cranberry	8.62
Viburnum edule	low-bush cranberry	84.48
Viburnum opulus	high-bush cranberry	1.72
Forb Stratum		
Achillea millefolium	common yarrow	12.07
Aralia nudicaulis	wild sarsaparilla	53.45
Arnica cordifolia	heart-leaved arnica	1.72
Aster ciliolatus	Lindley's aster	24.14
Aster conspicuus	showy aster	15.52
Athyrium filix-femina	lady fern	3.45
Botrychium virginianum	Virginia grapefern	1.72
Brachyactis species		12.07
Castilleja species		1.72
Circaea alpina	small enchanter's nightshade	6.90
Cirsium arvense	creeping thistle	1.72
Coptis trifolia	goldthread	5.17
Cornus canadensis	bunchberry	74.14
Delphinium glaucum	tall larkspur	5.17
Disporum trachycarpum	fairybells	6.90
Dryopteris assimilis	broad spinulose shield fern	1.72
Dryopteris carthusiana	narrow spinulose shield fern	12.07
Epilobium angustifolium	common fireweed	62.07
Epilobium palustre	marsh willowherb	1.72
Equisetum arvense	common horsetail	43.10
Equisetum fluviatile	swamp horsetail	1.72
Equisetum pratense	meadow horsetail	8.62
Equisetum scirpoides	dwarf scouring-rush	3.45
Equisetum species		3.45
Equisetum sylvaticum	woodland horsetail	22.41
Fragaria vesca	woodland strawberry	6.90
Fragaria virginiana	wild strawberry	62.07
Galeopsis tetrahit	hemp-nettle	1.72

Scientific name	Common name	Per cent occurrence
Galium boreale	northern bedstraw	44.83
Galium triflorum	sweet-scented bedstraw	39.66
Geocaulon lividum	northern bastard toadflax	3.45
Geum macrophyllum	large-leaved yellow avens	3.45
Goodyera repens	lesser rattlesnake plantain	8.62
Gymnocarpium dryopteris	oak fern	17.24
Hedysarum boreale	northern hedysarum	1.72
Hedysarum species		1.72
Heracleum lanatum	cow parsnip	6.90
Hieracium umbellatum	narrow-leaved hawkweed	3.45
Lathyrus ochroleucus	cream-colored vetchling	46.55
Listera cordata	heart-leaved twayblade	1.72
Lycopodium annotinum	stiff club-moss	8.62
Lycopodium obscurum	ground-pine	6.90
Maianthemum canadense	wild lily-of-the-valley	48.28
Mertensia paniculata	tall lungwort	67.24
Minuartia species		3.45
Mitella nuda	bishop's-cap	62.07
Moneses uniflora	one-flowered wintergreen	1.72
Orthilia secunda	one-sided wintergreen	13.79
Osmorhiza depauperata	spreading sweet cicely	3.45
Petasites frigidus var palmatus	palmate-leaved coltsfoot	65.52
Petasites frigidus var sagittatus	arrow-leaved coltsfoot	3.45
Platanthera hyperborea	northern green bog orchid	1.72
Pyrola asarifolia	common pink wintergreen	37.93
Pyrola chlorantha	greenish-flowered wintergreen	10.34
Pyrola species		6.90
Ranunculus lapponicus	Lapland buttercup	1.72
Smilacina trifolia	three-leaved Solomon's-seal	1.72
Solidago gigantea	late goldenrod	1.72
Solidago nemoralis	showy goldenrod	1.72
Solidago species		1.72
Stellaria species		1.72
Taraxacum officinale	common dandelion	6.90
Taraxacum species		1.72
Thalictrum venulosum	veiny meadowrue	3.45
Trientalis borealis	northern starflower	22.41
Trientalis europaea	arctic starflower	1.72
Trifolium pratense	red clover	1.72
Trifolium repens	white clover	1.72
Vicia americana	wild vetch	25.86
Viola adunca	early blue violet	1.72
Viola canadensis	western Canada violet	10.34

Scientific name	**Common name**	**Per cent occurrence**
Viola orbiculata	evergreen violet	1.72
Viola renifolia	kidney-leaved violet	34.48
Viola species		1.72
Grass Stratum		
Calamagrostis canadensis	bluejoint	77.59
Calamagrostis stricta	narrow reedgrass	1.72
Carex cordillerana		1.72
Carex deflexa	bent sedge	1.72
Carex deweyana	Dewey's sedge	1.72
Carex disperma	two-seeded sedge	1.72
Carex leptalea	bristle-stalked sedge	1.72
Carex norvegica	Norway sedge	1.72
Carex species		12.07
Carex trisperma	three-seeded sedge	1.72
Carex vaginata	sheathed sedge	3.45
Cinna latifolia	drooping wood-reed	1.72
Elymus glaucus	smooth wildrye	1.72
Glyceria striata	fowl manna grass	1.72
Leymus innovatus	hairy wildrye	22.41
Luzula multiflora	field wood-rush	1.72
Oryzopsis asperifolia	white-grained mountain rice grass	1.72
Oryzopsis species		1.72
Phleum pratense	timothy	1.72
Schizachne purpurascens	purple oatgrass	1.72
Scirpus microcarpus	small-fruited bulrush	1.72
Moss Stratum		
Abietinella abietina	wiry fern moss	1.72
Aulacomnium palustre	tufted moss/glow moss	8.62
Brachythecium rivulare	waterside feather moss	1.72
Calliergon cordifolium	heart-leaved feather moss	1.72
Climacium dendroides	common tree moss	5.17
Dicranum acutifolium	cushion moss	1.72
Dicranum flagellare	whip fork moss	1.72
Dicranum fragilifolium	cushion moss	5.17
Dicranum polysetum	electric eels	8.62
Dicranum species		1.72
Drepanocladus aduncus	common hook moss	1.72
Eurhynchium pulchellum	common beaked moss	6.90
Hylocomium splendens	stair-step moss	39.66
Mnium spinulosum	red-mouthed mnium	3.45
Plagiobothrys species		1.72

Scientific name	Common name	Per cent occurrence
Plagiomnium ciliare	toothed mnium	1.72
Plagiomnium cuspidatum	woodsy leafy moss	8.62
Plagiomnium drummondii	Drummond's leafy moss	5.17
Plagiomnium ellipticum	marsh magnificent moss	1.72
Plagiomnium medium	common leafy moss	1.72
Pleurozium schreberi	big red stem/Schreber's moss	44.83
Pohlia nutans	copper wire moss	1.72
Polytrichum commune	common hair-cap	18.97
Polytrichum juniperinum	juniper hair-cap	8.62
Polytrichum piliferum	awned hair-cap	1.72
Ptilidium pulcherrimum	(small wood) naugehyde liverwort	1.72
Ptilium crista-castrensis	knight's plume moss	34.48
Pylaisiella polyantha	stocking (aspen) moss	3.45
Rhizomnium gracile	slender round moss	1.72
Rhytidiadelphus triquetrus	electrified cats-tail moss	1.72
Sanionia uncinata	sickle moss/hook moss	5.17
Sphagnum capillifolium	acute-leaved peat moss	1.72
Sphagnum species		3.45
Sphagnum squarrosum	squarrose peat moss	1.72
Tomentypnum nitens	golden fuzzy fen moss	1.72
Lichen Stratum		
Alectoria sarmentosa	Common witch's hair	1.72
Cladina mitis	green/yellow reindeer lichen	6.90
Cladonia cariosa	ribbed cladonia/torn club cladonia	1.72
Cladonia chlorophaea	false pixie-cup	3.45
Cladonia cornuta	horn cladonia	1.72
Cladonia ecmocyna	orange-foot cladonia	3.45
Cladonia fimbriata	(tall false pixie-cup)	3.45
Cladonia gracilis		1.72
Cladonia multiformis	seive cladonia	1.72
Evernia mesomorpha	spuce moss/northern perfume	5.17
Hypocenomyce scalaris	common shingle	1.72
Hypogymnia physodes	monk's hood lichen/hooded tube	5.17
Nephroma resupinatum		1.72
Parmelia sulcata	waxpaper lichen/powdered shield	5.17
Peltigera aphthosa	freckle pelt/studded leather lichen	15.52
Peltigera canina	dog pelt/dog lichen	10.34
Peltigera elisabethae	(lobuled pelt)	1.72
Peltigera horizontalis		1.72
Peltigera malacea	apple pelt/boxboard felt lichen	1.72
Peltigera polydactyla		1.72
Peltigera rufescens	felt pelt	1.72
Usnea alpina	old man's beard	1.72

Scientific name	**Common name**	**Per cent occurrence**
Usnea hirta	sugary/shaggy old man's beard	1.72
Usnea lapponica	powdery old man's beard	1.72
Usnea species		1.72

denotes species for which fact sheets are available in Appendix F

Table I.8 Species list for ecosite f (60 plots for ecosite f)

Scientific name	Common name	Per cent occurrence
Tree Stratum		
Abies balsamea	balsam fir	25.00
Betula occidentalis	water birch	1.67
Betula papyrifera	white birch	55.00
Picea glauca	white spruce	85.00
Picea mariana	black spruce	6.67
Pinus banksiana	jack pine	3.33
Pinus contorta	lodgepole pine	1.67
Populus balsamifera	balsam poplar	50.00
Populus tremuloides	aspen	43.33
Shrub Stratum		
Actaea rubra	red and white baneberry	26.67
Alnus incana		1.67
Alnus incana ssp tenuifolia	river alder	25.00
Alnus viridis	green alder	15.00
Amelanchier alnifolia	saskatoon	15.00
Cornus stolonifera	red-osier dogwood	43.33
Ledum groenlandicum	common Labrador tea	20.00
Linnaea borealis	twinflower	60.00
Lonicera dioica	twining honeysuckle	11.67
Lonicera involucrata	bracted honeysuckle	28.33
Prunus pensylvanica	pin cherry	1.67
Ribes americanum	wild black currant	1.67
Ribes glandulosum	skunk currant	8.33
Ribes hudsonianum	northern blackcurrant	11.67
Ribes lacustre	bristly black currant	23.33
Ribes laxiflorum	mountain currant	1.67
Ribes oxyacanthoides	northern gooseberry	33.33
Ribes triste	wild redcurrant	28.33
Rosa acicularis	prickly rose	70.00
Rosa woodsii	common wild rose	5.00
Rubus arcticus	dwarf raspberry	10.00
Rubus chamaemorus	cloudberry	1.67
Rubus idaeus	wild red raspberry	30.00
Rubus pubescens	dewberry	63.33
Salix bebbiana	beaked willow	23.33
Salix discolor	pussy willow	5.00
Salix maccalliana	velvet-fruited willow	6.67
Salix myrtillifolia	myrtle-leaved willow	1.67

Scientific name	Common name	Per cent occurrence
Salix planifolia	flat-leaved willow	3.33
Salix pseudomonticola	false mountain willow	1.67
Salix scouleriana	Scouler's willow	5.00
Salix species		6.67
Shepherdia canadensis	Canada buffaloberry	10.00
Symphoricarpos albus	snowberry	13.33
Symphoricarpos occidentdis	buckbrush	1.67
Vaccinium myrtilloides	common blueberry	10.00
Vaccinium vitis-idaea	bog cranberry	23.33
Viburnum edule	low-bush cranberry	83.33
Forb Stratum		
Achillea millefolium	common yarrow	18.33
Aralia nudicaulis	wild sarsaparilla	41.67
Aster ciliolatus	Lindley's aster	23.33
Aster conspicuus	showy aster	5.00
Caltha palustris	marsh-marigold	5.00
Chrysosplenium iowense	golden saxifrage	1.67
Chrysosplenium tetrandrun	green saxifrage	1.67
Circaea alpina	small enchanter's nightshade	3.33
Corallorhiza trifida	pale coralroot	1.67
Cornus canadensis	bunchberry	70.00
Delphinium glaucum	tall larkspur	6.67
Diphasiastrum complanatum	ground-cedar	1.67
Dryopteris assimilis	broad spinulose shield fern	1.67
Dryopteris carthusiana	narrow spinulose shield fern	5.00
Epilobium angustifolium	common fireweed	51.67
Epilobium palustre	marsh willowherb	1.67
Equisetum arvense	common horsetail	56.67
Equisetum hyemale	common scouring-rush	1.67
Equisetum pratense	meadow horsetail	45.00
Equisetum scirpoides	dwarf scouring-rush	13.33
Equisetum sylvaticum	woodland horsetail	38.33
Fragaria virginiana	wild strawberry	36.67
Galium boreale	northern bedstraw	40.00
Galium trifidum	small bedstraw	5.00
Galium triflorum	sweet-scented bedstraw	23.33
Geocaulon lividum	northern bastard toadflax	13.33
Goodyera repens	lesser rattlesnake plantain	3.33
Gymnocarpium dryopteris	oak fern	3.33
Heracleum lanatum	cow parsnip	1.67
Hypericum species		1.67
Lathyrus ochroleucus	cream-colored vetchling	21.67
Lathyrus venosus	purple peavine	1.67
Lycopodium annotinum	stiff club-moss	13.33

Scientific name	Common name	Per cent occurrence
Lycopodium obscurum	ground-pine	1.67
Maianthemum canadense	wild lily-of-the-valley	31.67
Mertensia paniculata	tall lungwort	75.00
Mitella nuda	bishop's-cap	73.33
Moehringia lateriflora	blunt-leaved sandwort	1.67
Moneses uniflora	one-flowered wintergreen	5.00
Orthilia secunda	one-sided wintergreen	23.33
Pedicularis labradorica	Labrador lousewort	1.67
Petasites frigidus	arctic sweet coltsfoot	1.67
Petasites frigidus var *frigidus*	sweet coltsfoot	1.67
Petasites frigidus var *palmatus*	palmate-leaved coltsfoot	63.33
Plagiobothrys species		1.67
Platanthera hyperborea	northern green bog orchid	1.67
Platanthera obtusata	blunt-leaved bog orchid	3.33
Platanthera orbiculata	round-leaved bog orchid	1.67
Pyrola asarifolia	common pink wintergreen	33.33
Pyrola chlorantha	greenish-flowered wintergreen	6.67
Ranunculus acris	tall buttercup	1.67
Ranunculus lapponicus	Lapland buttercup	1.67
Scutellaria galericulata	marsh skullcap	1.67
Stellaria longifolia	long-leaved chickweed	3.33
Stellaria longipes	long-stalked chickweed	1.67
Taraxacum officinale	common dandelion	3.33
Thalictrum dasycarpum	tall meadowrue	3.33
Thalictrum venulosum	veiny meadowrue	13.33
Trientalis borealis	northern starflower	20.00
Trientalis europaea	arctic starflower	5.00
Urtica dioica	common nettle	3.33
Vicia americana	wild vetch	18.33
Viola canadensis	western Canada violet	3.33
Viola palustris	marsh violet	3.33
Viola renifolia	kidney-leaved violet	31.67
Grass Stratum		
Bromus inermis	awnless brome	1.67
Bromus inermis ssp *pumpellianus*		1.67
Calamagrostis canadensis	bluejoint	65.00
Carex concinna	beautiful sedge	1.67
Carex disperma	two-seeded sedge	8.33
Carex species		3.33
Carex vaginata	sheathed sedge	3.33
Glyceria borealis	northern manna grass	1.67

Scientific name	Common name	Per cent occurrence
Leymus innovatus	hairy wildrye	8.33
Leymus innovatus	hairy wildrye	3.33
Poa species		1.67
Schizachne purpurascens	purple oatgrass	3.33
Typha latifolia	common cattail	1.67
Moss Stratum		
Amblystegium riparium		1.67
Aulacomnium palustre	tufted moss/glow moss	11.67
Brachythecium starkei		3.33
Brachythecium velutinum	velvet feather moss	3.33
Bryum pallescens		1.67
Bryum species		1.67
Climacium dendroides	common tree moss	5.00
Dicranum fuscescens	curly heron's bill moss	5.00
Dicranum polysetum	electric eels	3.33
Dicranum species		1.67
Dicranum undulatum	wavy dicranum	1.67
Eurhynchium pulchellum	common beaked moss	8.33
Hylocomium species		1.67
Hylocomium splendens	stair-step moss	65.00
Hypnum cupressiforme	cypress pigtail moss	1.67
Jamesoniella autumnalis	Jameson's liverwort	1.67
Liverwort		1.67
Mnium spinulosum	red-mouthed mnium	1.67
Moss		1.67
Plagiomnium cuspidatum	woodsy leafy moss	6.67
Plagiomnium ellipticum	marsh magnificent moss	10.00
Plagiomnium medium	common leafy moss	1.67
Pleurozium schreberi	big red stem/Schreber's moss	18.33
Pohlia nutans	copper wire moss	5.00
Polytrichum juniperinum	juniper hair-cap	1.67
Polytrichum piliferum	awned hair-cap	1.67
Ptilidium pulcherrimum	(small wood) naugehyde liverwort	3.33
Ptilium crista-castrensis	knight's plume moss	43.33
Pylaisiella polyantha	stocking (aspen) moss	11.67
Sanionia uncinata	sickle moss/hook moss	3.33
Sphagnum species		3.33
Sphagnum squarrosum	squarrose peat moss	1.67
Thuidium recognitum	hook-leaf fern moss	1.67
Tomentypnum nitens	golden fuzzy fen moss	3.33

Scientific name	Common name	Per cent occurrence
Lichen Stratum		
Bryoria glabra		3.33
Ceratodon purpureus	purple horn-toothed moss	6.67
Cetraria pinastri		1.67
Cetraria platyphylla Tuck		1.67
Cladina mitis	green/yellow reindeer lichen	3.33
Cladonia amaurocraea	(cup-forming prickle cladonia)	1.67
Cladonia cornuta	horn cladonia	1.67
Cladonia crispata	shrub funnel cladonia	1.67
Cladonia deformis	deformed cup	1.67
Cladonia gracilis ssp *turbinata*	brown-foot cladonia	3.33
Cladonia macilenta	scarlet toothpick cladonia	1.67
Cladonia multiformis	seive cladonia	1.67
Cladonia uncialis	prickle cladonia	1.67
Evernia mesomorpha	spuce moss/northern perfume	5.00
Hypogymnia austerodes		1.67
Hypogymnia enteromorpha		1.67
Hypogymnia physodes	monk's hood lichen/hooded tube	5.00
Lecanora impudens		1.67
Parmelia sulcata	waxpaper lichen/powdered shield	8.33
Peltigera aphthosa	freckle pelt/studded leather lichen	10.00
Peltigera canina	dog pelt/dog lichen	1.67
Peltigera elisabethae	(lobuled pelt)	1.67
Peltigera leucophlebia	(veined freckle pelt)	1.67
Peltigera neopolydactyla	frog pelt/finger felt lichen	1.67
Peltigera polydactyla		3.33
Peltigera species		1.67
Usnea alpina	old man's beard	5.00
Usnea hirta	sugary/shaggy old man's beard	3.33
Usnea lapponica	powdery old man's beard	3.33

denotes species for which fact sheets are available in Appendix F

Table I.9 Species list for ecosite g (43 plots for ecosite g)

Scientific name	Common name	Per cent occurrence
Tree Stratum		
Abies balsamea	balsam fir	4.65
Betula glandulosa	bog birch	6.98
Betula papyrifera	white birch	23.26
Betula pumila	dwarf birch	4.65
Larix laricina	tamarack	11.63
Picea glauca	white spruce	4.65
Picea mariana	black spruce	51.16
Pinus banksiana	jack pine	18.60
Pinus contorta	lodgepole pine	11.63
Populus balsamifera	balsam poplar	6.98
Populus tremuloides	aspen	41.86
Shrub Stratum		
Alnus viridis	green alder	6.98
Amelanchier alnifolia	saskatoon	6.98
Arctostaphylos rubra	alpine bearberry	4.65
Arctostaphylos uva-ursi	common bearberry	6.98
Empetrum nigrum	crowberry	6.98
Ledum groenlandicum	common Labrador tea	81.40
Linnaea borealis	twinflower	34.88
Lonicera dioica	twining honeysuckle	2.33
Lonicera involucrata	bracted honeysuckle	6.98
Oxycoccus microcarpus	small bog cranberry	4.65
Potentilla fruticosa	shrubby cinquefoil	2.33
Ribes hudsonianum	northern blackcurrant	2.33
Rosa acicularis	prickly rose	46.51
Rosa woodsii	common wild rose	4.65
Rubus arcticus	dwarf raspberry	4.65
Rubus chamaemorus	cloudberry	16.28
Rubus pubescens	dewberry	4.65
Salix bebbiana	beaked willow	20.93
Salix discolor	pussy willow	2.33
Salix myrtillifolia	myrtle-leaved willow	20.93
Salix pedicellaris	bog willow	2.33
Salix planifolia	flat-leaved willow	6.98
Salix pyrifolia	balsam willow	9.30
Salix scouleriana	Scouler's willow	6.98
Salix species		4.65
Shepherdia canadensis	Canada buffaloberry	6.98
Symphoricarpos albus	snowberry	2.33
Vaccinium caespitosum	dwarf bilberry	6.98
Vaccinium myrtilloides	common blueberry	55.81

Scientific name	Common name	Per cent occurrence
Vaccinium vitis-idaea	bog cranberry	76.74
Viburnum edule	low-bush cranberry	4.65
Forb Stratum		
Achillea millefolium	common yarrow	9.30
Aster ciliolatus	Lindley's aster	11.63
Campanula rotundifolia	harebell	6.98
Chrysanthemum leucanthemum	ox-eye daisy	2.33
Corallorhiza trifida	pale coralroot	2.33
Cornus canadensis	bunchberry	46.51
Diphasiastrum complanatum	ground-cedar	6.98
Epilobium angustifolium	common fireweed	27.91
Epilobium palustre	marsh willowherb	2.33
Equisetum arvense	common horsetail	18.60
Equisetum pratense	meadow horsetail	4.65
Equisetum scirpoides	dwarf scouring-rush	13.95
Equisetum sylvaticum	woodland horsetail	51.16
Fragaria vesca	woodland strawberry	2.33
Fragaria virginiana	wild strawberry	13.95
Galium boreale	northern bedstraw	4.65
Geocaulon lividum	northern bastard toadflax	25.58
Goodyera repens	lesser rattlesnake plantain	2.33
Hypericum species		2.33
Lathyrus venosus	purple peavine	2.33
Listera borealis	northern twayblade	2.33
Listera cordata	heart-leaved twayblade	2.33
Lycopodium annotinum	stiff club-moss	13.95
Lycopodium clavatum	running club-moss	4.65
Lycopodium obscurum	ground-pine	4.65
Maianthemum canadense	wild lily-of-the-valley	9.30
Melampyrum lineare	cow-wheat	4.65
Mertensia paniculata	tall lungwort	4.65
Mitella nuda	bishop's-cap	16.28
Moneses uniflora	one-flowered wintergreen	2.33
Orthilia secunda	one-sided wintergreen	9.30
Parnassia palustris	northern grass-of-parnassus	4.65
Pedicularis labradorica	Labrador lousewort	6.98
Petasites frigidus	arctic sweet coltsfoot	4.65
Petasites frigidus var frigidus	sweet coltsfoot	2.33
Petasites frigidus var palmatus	palmate-leaved coltsfoot	39.53
Platanthera hyperborea	northern green bog orchid	2.33
Polygonum convolvulus	wild buckwheat	2.33
Potentilla tridentata	three-toothed cinquefoil	2.33

Scientific name	Common name	Per cent occurrence
Pyrola chlorantha	greenish-flowered wintergreen	2.33
Pyrola species		2.33
Saxifraga tricuspidata	three-toothed saxifrage	2.33
Senecio indecorus	rayless ragwort	2.33
Smilacina trifolia	three-leaved Solomon's-seal	6.98
Trientalis borealis	northern starflower	6.98
Trifolium pratense	red clover	2.33
Viola nephrophylla	bog violet	2.33
Viola renifolia	kidney-leaved violet	6.98
Grass Stratum		
Bromus inermis	awnless brome	2.33
Calamagrostis canadensis	bluejoint	27.91
Carex aquatilis	water sedge	9.30
Carex brunnescens	brownish sedge	2.33
Carex disperma	two-seeded sedge	9.30
Carex species		4.65
Carex vaginata	sheathed sedge	2.33
Eriophorum gracile	slender cottongrass	2.33
Leymus innovatus	hairy wildrye	16.28
Oryzopsis pungens	northern rice grass	2.33
Moss Stratum		
Aulacomnium palustre	tufted moss/glow moss	34.88
Brachythecium salebrosum	golden ragged moss	2.33
Bryum species		4.65
Ceratodon purpureus	purple horn-toothed moss	2.33
Dicranum acutifolium	cushion moss	2.33
Dicranum fuscescens	curly heron's bill moss	4.65
Dicranum polysetum	electric eels	11.63
Dicranum species		4.65
Dicranum undulatum	wavy dicranum	34.88
Eurhynchium pulchellum	common beaked moss	2.33
Helodium blandowii	Blandow's feather moss	2.33
Hylocomium species		4.65
Hylocomium splendens	stair-step moss	76.74
Lepidozia reptans	little hands liverwort	2.33
Liverwort		2.33
Moss		6.98
Platygyrium repens		2.33
Pleurozium schreberi	big red stem/Schreber's moss	46.51
Pohlia nutans	copper wire moss	2.33

Scientific name	**Common name**	**Per cent occurrence**
Polytrichum commune	common hair-cap	6.98
Polytrichum juniperinum	juniper hair-cap	16.28
Polytrichum piliferum	awned hair-cap	2.33
Polytrichum strictum	slender hair-cap	9.30
Ptilidium pulcherrimum	(small wood) naugehyde liverwort	4.65
Ptilium crista-castrensis	knight's plume moss	46.51
Pylaisiella polyantha	stocking (aspen) moss	4.65
Sanionia uncinata	sickle moss/hook moss	2.33
Sphagnum angustifolium	poor fen peat moss	2.33
Sphagnum capillifolium	acute-leaved peat moss	2.33
Sphagnum fuscum	rusty peat moss	4.65
Sphagnum species		2.33
Sphagnum warnstorfii	Warnstorf's peat moss	2.33
Tomentypnum nitens	golden fuzzy fen moss	11.63
Lichen Stratum		
Arthonia patellulata	aspen comma	2.33
Bryoria glabra		4.65
Cetraria pinastri		2.33
Cladina mitis	green/yellow reindeer lichen	55.81
Cladina portentosa	reindeer lichen	2.33
Cladina rangiferina	grey reindeer lichen	34.88
Cladina stellaris	northern/star reindeer lichen	9.30
Cladina stygia	(black-based) reindeer lichen	4.65
Cladonia bacilliformis	yellow tiny toothpick cladonia	2.33
Cladonia botrytes	stump cladonia	4.65
Cladonia cenotea	powdered funnel cladonia	2.33
Cladonia chlorophaea	false pixie-cup	2.33
Cladonia coccifera	British soldier lichen	2.33
Cladonia cornuta	horn cladonia	20.93
Cladonia crispata	shrub funnel cladonia	2.33
Cladonia cristatella	(skinny) British soldiers	6.98
Cladonia deformis	deformed cup	16.28
Cladonia fimbriata	(tall false pixie-cup)	4.65
Cladonia gracilis		4.65
Cladonia gracilis ssp *turbinata*	brown-foot cladonia	25.58
Cladonia multiformis	seive cladonia	4.65
Cladonia phyllophora	black-foot cladonia	2.33
Cladonia species		9.30
Cladonia sulphurina	sulphur cup	11.63
Cladonia uncialis	prickle cladonia	2.33
Evernia mesomorpha	spuce moss/northern perfume	2.33

Scientific name	**Common name**	**Per cent occurrence**
Flavocetraria nivalis	flattened snow lichen	2.33
Hypogymnia physodes	monk's hood lichen/hooded tube	6.98
Icmadophila ericetorum	fairy puke/spraypaint	2.33
Micarea prasina		2.33
Parmelia sulcata	waxpaper lichen/powdered shield	2.33
Parmeliopsis hyperopta	grey starburst	2.33
Peltigera aphthosa	freckle pelt/studded leather lichen	51.16
Peltigera didactyla	temporary pelt/small felt lichen	4.65
Peltigera kristinssonii		2.33
Peltigera leucophlebia	(veined freckle pelt)	4.65
Peltigera neopolydactyla	frog pelt/finger felt lichen	16.28
Peltigera scabrosa	rough pelt	2.33
Peltigera species		2.33
Trapeliopsis granulosa		2.33
Usnea alpina	old man's beard	4.65
Usnea hirta	sugary/shaggy old man's beard	4.65
Usnea lapponica	powdery old man's beard	4.65

denotes species for which fact sheets are available in Appendix F

Table I.10 Species list for ecosite h (25 plots for ecosite h)

Scientific name	Common name	Per cent occurrence
Tree Stratum		
Abies balsamea	balsam fir	4.00
Betula papyrifera	white birch	24.00
Betula pumila	dwarf birch	8.00
Larix laricina	tamarack	4.00
Picea glauca	white spruce	84.00
Picea mariana	black spruce	52.00
Pinus banksiana	jack pine	4.00
Pinus contorta	lodgepole pine	4.00
Populus balsamifera	balsam poplar	20.00
Populus tremuloides	aspen	36.00
Shrub Stratum		
Actaea rubra	red and white baneberry	12.00
Alnus incana ssp tenuifolia	river alder	12.00
Alnus viridis	green alder	12.00
Amelanchier alnifolia	saskatoon	4.00
Arctostaphylos rubra	alpine bearberry	4.00
Arctostaphylos uva-ursi	common bearberry	4.00
Cornus stolonifera	red-osier dogwood	8.00
Ledum groenlandicum	common Labrador tea	84.00
Linnaea borealis	twinflower	52.00
Lonicera dioica	twining honeysuckle	8.00
Lonicera involucrata	bracted honeysuckle	20.00
Oxycoccus microcarpus	small bog cranberry	4.00
Ribes glandulosum	skunk currant	4.00
Ribes hudsonianum	northern blackcurrant	12.00
Ribes lacustre	bristly black currant	28.00
Ribes oxyacanthoides	northern gooseberry	12.00
Ribes triste	wild redcurrant	12.00
Rosa acicularis	prickly rose	68.00
Rosa woodsii	common wild rose	4.00
Rubus arcticus	dwarf raspberry	32.00
Rubus chamaemorus	cloudberry	16.00
Rubus idaeus	wild red raspberry	8.00
Rubus pubescens	dewberry	32.00
Salix arbusculoides	shrubby willow	4.00
Salix bebbiana	beaked willow	36.00
Salix drummondiana	Drummond's willow	4.00
Salix myrtillifolia	myrtle-leaved willow	20.00
Salix pedicellaris	bog willow	4.00
Salix planifolia	flat-leaved willow	12.00
Salix pyrifolia	balsam willow	16.00

Scientific name	Common name	Per cent occurrence
Salix species		4.00
Shepherdia canadensis	Canada buffaloberry	24.00
Vaccinium myrtilloides	common blueberry	20.00
Vaccinium vitis-idaea	bog cranberry	80.00
Viburnum edule	low-bush cranberry	36.00
Forb Stratum		
Achillea millefolium	common yarrow	32.00
Aster ciliolatus	Lindley's aster	20.00
Aster puniceus	purple-stemmed aster	4.00
Astragalus canadensis	Canadian milkvetch	8.00
Caltha palustris	marsh-marigold	8.00
Campanula rotundifolia	harebell	4.00
Corallorhiza trifida	pale coralroot	8.00
Cornus canadensis	bunchberry	60.00
Epilobium angustifolium	common fireweed	36.00
Epilobium palustre	marsh willowherb	4.00
Equisetum arvense	common horsetail	60.00
Equisetum pratense	meadow horsetail	24.00
Equisetum scirpoides	dwarf scouring-rush	36.00
Equisetum sylvaticum	woodland horsetail	60.00
Fragaria virginiana	wild strawberry	32.00
Galium boreale	northern bedstraw	16.00
Galium trifidum	small bedstraw	4.00
Galium triflorum	sweet-scented bedstraw	16.00
Geocaulon lividum	northern bastard toadflax	36.00
Goodyera repens	lesser rattlesnake plantain	4.00
Lathyrus ochroleucus	cream-colored vetchling	12.00
Lathyrus venosus	purple peavine	4.00
Listera cordata	heart-leaved twayblade	4.00
Lycopodium annotinum	stiff club-moss	24.00
Maianthemum canadense	wild lily-of-the-valley	12.00
Mertensia paniculata	tall lungwort	48.00
Microseris nutans	nodding scorzonella	4.00
Mitella nuda	bishop's-cap	52.00
Moneses uniflora	one-flowered wintergreen	8.00
Orthilia secunda	one-sided wintergreen	40.00
Petasites frigidus	arctic sweet coltsfoot	4.00
Petasites frigidus var frigidus	sweet coltsfoot	4.00
Petasites frigidus var palmatus	palmate-leaved coltsfoot	60.00
Plagiobothrys species		4.00
Platanthera hyperborea	northern green bog orchid	4.00
Platanthera orbiculata	round-leaved bog orchid	8.00

Scientific name	**Common name**	**Per cent occurrence**
Potentilla palustris	marsh cinquefoil	4.00
Pyrola asarifolia	common pink wintergreen	20.00
Pyrola chlorantha	greenish-flowered wintergreen	8.00
Ranunculus lapponicus	Lapland buttercup	12.00
Ranunculus macounii	Macoun's buttercup	4.00
Senecio pauciflorus	few-flowered ragwort	4.00
Smilacina trifolia	three-leaved Solomon's-seal	24.00
Solidago simplex ssp *simplex*	mountain goldenrod	4.00
Spiranthes romanzoffiana	hooded ladies'-tresses	8.00
Taraxacum officinale	common dandelion	4.00
Trientalis borealis	northern starflower	20.00
Trientalis europaea	arctic starflower	8.00
Vicia americana	wild vetch	16.00
Viola canadensis	western Canada violet	4.00
Viola palustris	marsh violet	4.00
Viola renifolia	kidney-leaved violet	16.00
Grass Stratum		
Bromus inermis ssp *pumpellianus*		8.00
Calamagrostis canadensis	bluejoint	32.00
Carex aquatilis	water sedge	4.00
Carex aurea	golden sedge	4.00
Carex brunnescens	brownish sedge	4.00
Carex disperma	two-seeded sedge	20.00
Carex gynocrates	northern bog sedge	4.00
Carex pauciflora	few-flowered sedge	4.00
Carex species		8.00
Carex tenera	broad-fruited sedge	4.00
Carex vaginata	sheathed sedge	12.00
Leymus innovatus	hairy wildrye	24.00
Poa palustris	fowl bluegrass	4.00
Poa species		4.00
Moss Stratum		
Amblystegium serpens		4.00
Aulacomnium palustre	tufted moss/glow moss	48.00
Brachythecium starkei		4.00
Calliergon richardsonii	Richardson's water moss	4.00
Ceratodon purpureus	purple horn-toothed moss	4.00
Cinclidium stygium	common northen lantern moss	8.00
Climacium dendroides	common tree moss	4.00
Dicranum fuscescens	curly heron's bill moss	12.00
Dicranum polysetum	electric eels	16.00

Scientific name	Common name	Per cent occurrence
Dicranum undulatum	wavy dicranum	20.00
Drepanocladus species		4.00
Helodium blandowii	Blandow's feather moss	4.00
Hylocomium species		4.00
Hylocomium splendens	stair-step moss	96.00
Marchantia polymorpha	green-tongue liverwort	4.00
Plagiomnium cuspidatum	woodsy leafy moss	4.00
Plagiomnium drummondii	Drummond's leafy moss	4.00
Plagiomnium ellipticum	marsh magnificent moss	12.00
Plagiomnium species		4.00
Pleurozium schreberi	big red stem/Schreber's moss	52.00
Pohlia nutans	copper wire moss	4.00
Polytrichum juniperinum	juniper hair-cap	8.00
Polytrichum strictum	slender hair-cap	12.00
Ptilidium pulcherrimum	(small wood) naugehyde liverwort	8.00
Ptilium crista-castrensis	knight's plume moss	44.00
Pylaisiella polyantha	stocking (aspen) moss	8.00
Sanionia uncinata	sickle moss/hook moss	4.00
Sphagnum angustifolium	poor fen peat moss	20.00
Sphagnum capillifolium	acute-leaved peat moss	4.00
Sphagnum fuscum	rusty peat moss	12.00
Sphagnum squarrosum	squarrose peat moss	4.00
Tomentypnum nitens	golden fuzzy fen moss	16.00
Lichen Stratum		
Bryoria fuscescens	speckled horsehair	4.00
Bryoria glabra		8.00
Cetraria platyphylla Tuck		4.00
Cladina mitis	green/yellow reindeer lichen	28.00
Cladina stellaris	northern/star reindeer lichen	8.00
Cladonia chlorophaea	false pixie-cup	8.00
Cladonia coniocraea	tiny toothpick cladonia	4.00
Cladonia cornuta	horn cladonia	8.00
Cladonia cristatella	(skinny) British soldiers	8.00
Cladonia deformis	deformed cup	4.00
Cladonia fimbriata	(tall false pixie-cup)	12.00
Cladonia gracilis ssp *turbinata*	brown-foot cladonia	8.00
Cladonia sulphurina	sulphur cup	4.00
Evernia mesomorpha	spuce moss/northern perfume	8.00
Hypogymnia physodes	monk's hood lichen/hooded tube	12.00
Parmelia sulcata	waxpaper lichen/powdered shield	4.00
Peltigera aphthosa	freckle pelt/studded leather lichen	32.00
Peltigera malacea	apple pelt/boxboard felt lichen	4.00
Peltigera neckeri	(shiny powdered pelt)	4.00

Scientific name	Common name	Per cent occurrence
Peltigera rufescens	felt pelt	4.00
Peltigera scabrosa	rough pelt	4.00
Usnea alpina	old man's beard	4.00
Usnea hirta	sugary/shaggy old man's beard	8.00
Usnea lapponica	powdery old man's beard	8.00

denotes species for which fact sheets are available in Appendix F

References

Geographic Dynamics Corp. (GDC) 2009. Characteristic Species Thresholds: Ecosites f, g , and h. A Supplemental Report to the Vegetation data synthesis in the Athabasca Oil Sands Region. Prepared for: Cumulative Environmental Management Association (CEMA) Reclamation Working Group (RWG) Soil/Vegetation Subgroup (SVSG).

Geographic Dynamics Corp. & FORRx Consulting Inc. (GDC and FORRx) 2008. Vegetation data synthesis in the Athabasca Oil Sands Region. Prepared for: Cumulative Environmental Management Association (CEMA) Reclamation Working Group (RWG) Soil/Vegetation Subgroup (SVSG).

Appendix J—Estimating Ecosite Based on Species Lists

Assessing the site type designation

Site types are groups of ecosites that have similar ecological characteristics. In principle, ecosites are defined by characteristics of their moisture and nutrient regime; thus, site type groupings encompass a broader range of moisture and nutrient regimes, hence their position on the Edatopic Grid (see Figure 3-2 in Section 3). In practice, ecosites (and hence, site types) are also defined by their associated plant species, since their presence is, in part, a reflection of the actual edatopic conditions.

One of the decisions in developing a site-specific revegetation program is establishing the target site type (see Sections 4 and 5). A variance in site type from the assumed target suggests that:

a) The edatopic position originally derived from the LCCS under the site type approach may not have been accurate (see Figure 2-1 in Section 2);
b) In the case of the land-use approach, the capping prescriptions developed in conjunction with the LCCS did not generate the appropriate edatopic position (see Figure 2-2 in Section 2); or
c) The revegetation treatment was not successful.

Changing the site type designation can also have important implications for the inherent productive capacity of a site, which could affect the end land-use designation (see Section 4.1 for details on how this is declared).

It is the site type that dictates the anticipated species complement in the reclaimed ecosystem (see Section 5.3.3). Hence, evaluating site-type requires a comparison of the realized community composition with that anticipated from the original site type target. This is largely a qualitative exercise necessitated by the fact that there is a considerable overlap in characteristic species among site types (and their corresponding ecosites; see Table 3-1 in Section 3). Nevertheless, there are one or more species unique to each site type, and these are used in making the final site type designation. Tables 5-4 through 5-8 provide a comparison of the species assemblages characteristic of dry (Table 5-4), moist poor (Table 5-5), moist rich (Table 5-6), wet poor (Table 5-7) and wet rich (Table 5-8) site types. To use these tables, first tabulate the species present on a given reclaimed area. These are the same data as would be collected when monitoring for plant community composition (see Section 5.3 and Appendix B). Second, check each species present against the lists provided in Tables 5-4 through 5-8. For example, in comparing dry versus moist poor site types, there are 12 species unique to the dry site type (see Table 5-4) and six species unique to the moist poor site type (see Table 5-5). Tabulate the number of species unique to each site type and express this number as a proportion of the total number of unique species (within a given site type). Finally, compare each proportion to determine which site type contains the most unique species. In determining which site type is best represented by the species list, less emphasis should be accorded to species that were a component of the planting program in favor of species present on the site due to natural ingress. Evaluate whether the original site type designation should be retained. If results indicate the necessity for a change in site type then an evaluation of the principal end land-use should also be undertaken (see Section 4.1). Table 5-3 in Section 5.3.3 provides the minimum threshold values of characteristic species by site type. Sites that do not meet these threshold values have less than a 5% chance of being comparable to a "locally common boreal forest" population in terms of vegetation community composition.

Ecosite: refining the site type designation

During the early phase of reclamation, plant community composition is highly dynamic (as a result of ingress and as populations expand or contract), with the result that there is a high degree of uncertainty in the developmental trajectory. Thus, applying a site type designation represents an appropriate level of resolution at this stage. When growing space eventually becomes limiting and the tree canopy reaches full development, community composition will stabilize; however, at this point, it will be possible to refine the site type designation and classify sites down to the ecosite level.

To evaluate if an ecosite is developing on a reclaimed site, the following method is recommended based on the vegetation data synthesis completed by Geographics Dynamics Corp. for CEMA (GDC and FORRx 2008).

Ecosites are tied to a capability classification and they integrate the dominant controlling factors of moisture regime and nutrient regime. A reclaimed site should be converging, in the value of its key environmental indicators, with the mature natural ecosite of the same type. The key indicators of overstory and understory development should be sensitive to the ecosites and easy to measure.

The following indicator variables are recommended for evaluating ecosite establishment:

1. Site index,
2. Tree height,
3. Dominant plant species (percent cover and prominence),
4. Species richness, and
5. Ecosite characteristic species.

Ecosite indicates the availability of moisture and nutrients for plant growth. Based on site index by species and ecosite, GDC predicted tree height growth by using tree height-site index models (GDC and FORRx 2008). Grouped by ecosite, the mean and range of variability of tree height can be used as a temporal benchmark (see GDC and FORRx 2008, Appendix D, Figures D.6 to D.8) for monitoring and assessing reclaimed sites. This is accomplished by plotting measured height with predicted height, and can be done simultaneously for all ecosites to determine which ecosite, or range of ecosites, are indicated.

Repeated measurements over time can be plotted together to visualize plot developmental trajectories. The environmental characteristics of the community are incorporated at the ecosite level. While plant communities throughout the boreal mixedwood subregion share some general vegetation similarities, the communities often show differences in understory species composition and abundance. The Field Guide to Ecosite of Northern Alberta (Beckingham and Archibald 1995) lists characteristic ecosite species for each ecosite in the boreal mixedwood ecological subregion. These species may be used as indicators for ecosite. Using monitoring plot survey data, the number of ecosite characteristic species, total percent cover and percent of ecosite characteristic species (from an ecosite characteristic species list; see Section 4 for ecosite characteristic species and Section 5 for site type characteristic species) can be integrated to aid in discerning ecosite. Table J.1 is an example (using actual plot data from the oil sands region) of how characteristic species may be used to help identify ecosite. In the example shown in Table J.1, ecosite e is most likely with ecosite d as a possible alternative. The recommended labeling convention is one that incorporates most likely and alternative ecosite, in parenthesis, followed by the age at assessment. In the example shown in Table J.1, the label would be "e(d) 35".

Table J.1 **An example of ecosite indication using real plot data. Stand (plot) age is 35**

Row Number	Species Code	Stratum	Cover	Ecosite Characteristic Species				
				a	b	c	d	e
1	AMELALN	shrub	5		5		5	5
	ARALNUD	forb	2		2		2	2
	ASTECIL	forb	2					
	ASTECON	forb	2				2	
	CALACAN	graminoid	15		15		15	15
	CORNCAN	forb	5		5	5	5	5
	CORNSTO	shrub	7					7
	EPILANG	forb	10		10		10	10
	EQUIARV	forb	1					1
	FRAGVIR	forb	1				1	
	GALIBOR	forb	1					
	1 GALITRI	forb	1				1	
	HERALAN	forb	1					
	LATHOCH	forb	1				1	
	LINNBOR	shrub	2	2	5	2	2	2
	LONIDIO	shrub	1					
	LONIINV	shrub	10					10
	MERTPAN	forb	1				1	1
	MITENUD	forb	1				1	1
	PETAPAL	forb	10				10	
	POPUBAL	tree	7				7	7
	POPUTRE	tree	30		30		30	30
	RIBEGLA	shrub	1					1
	RIBEOXY	shrub	2				2	2
	RIBETRI	shrub	1				1	
	ROSAACI	shrub	20		20	20	20	20
	ROSAWOO	shrub	10					
	RUBUIDA	shrub	2				2	2
	RUBUPUB	forb	5				5	5
	SALIBEB	shrub	15		15	15	15	15
	SHEPCAN	shrub	3		3		3	
	SYMPALB	shrub	2				2	
	VIBUEDU	shrub	5				5	5
	VICIAME	forb	1					
	VIOLREN	forb	1					
2	Count			1	10	4	24	20
3	% of Ecosite Characteristic Species			7	32	15	52	56
4	Total Species % Cover			2	107	42	148	146
5	Ecosite						(d)	e

Row 1: species from the plot with strata, percent cover.
Row 2: how many ecosite characteristics the plot has for each ecosite.
Row 3: percent of ecosite characteristic species. For ecosite a there are 14 characteristic species, b 31 species, c 27 species, d 46 species, and ecosite e has 36 characteristic species. (count /number of characteristic X 100)
Row 4: total percent cover of characteristic species.
Row 5: assessment result shows this plot could be ecosite e or d.

References

Beckingham, JD & Archibald, JH. 1995. Field Guide to Ecosites of Northern Alberta. UBC Press.

Geographic Dynamics Corp. & FORRx Consulting Inc. (GDC and FORRx) 2008. Vegetation Data Synthesis in the Athabasca Oil Sands Region. Prepared for: Cumulative Environmental Management Association (CEMA) Reclamation Working Group (RWG) Soil/Vegetation Subgroup (SVSG).